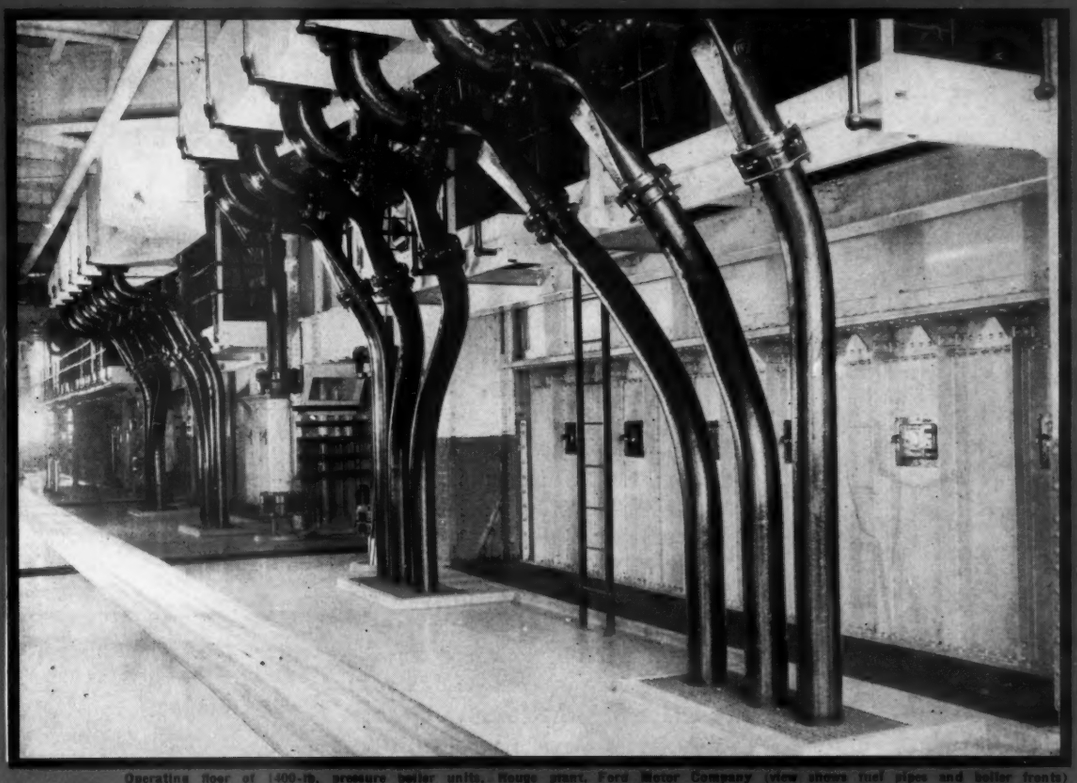
COMBUSTION

Vol. 4, No. 10 APRIL, 1933 APR 11 1933 25c a copy



Operating floor of 1400-lb. pressure boiler units, Rouge plant, Ford Motor Company (view shows fuel pipes and boiler fronts)

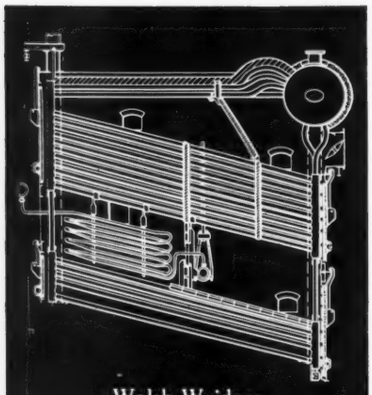
MECHANICAL DRAFT FANS

•

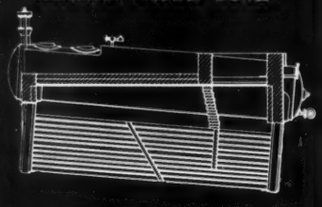
THE SELECTION OF STOKERS

•

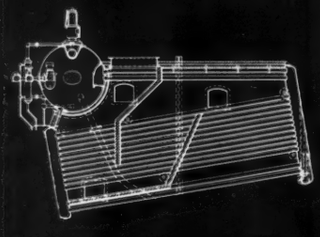
SLIME AND MUSSEL CONTROL IN SURFACE CONDENSERS AND CIRCULATING WATER TUNNELS



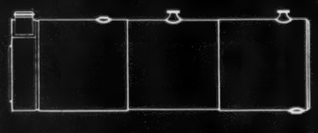
Walsh-Weidner
Sectional Header Boiler



Heine Long-Drum Boiler

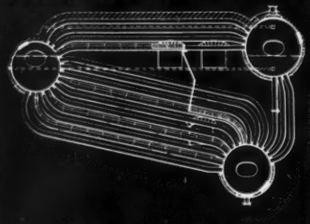


Heine Cross-Drum Boiler



Hedges-Walsh-Weidner h.r.t. Boiler

Hedges-Walsh-Weidner
Premier Semi-Portable Boiler



C-E Low-Head Boiler

BOILERS

All Types - All Sizes

THE boiler buyer of today has a more complex problem than ever in selecting from the many types of boilers on the market the one that is best suited to his conditions and that represents the best in design and workmanship for the amount he can spend.

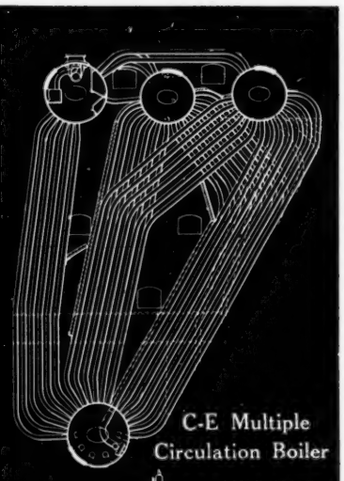
Combustion Engineering Corporation can help him reach the right decision. It can suit his preference and his needs because it manufactures all types and sizes of boilers. It can assure him the best in design because its designs are based on years of intimate contact with every development in steam generation, and their merit is evidenced in the repeated selection of its boilers by the engineers of the largest utility and industrial corporations. Leadership in this respect is further evidenced by the fact that C-E installations include the largest bent-tube, the largest sectional-header and the highest pressure boilers in operation in the country today. It can offer him the best in quality of workmanship because there are no better equipped boiler shops anywhere than its Hedges-Walsh-Weidner and Heine plants. And finally, by reason of its extensive experience with fuels and methods of firing, it can assist him in relating his boiler design and fuel-burning equipment so as to assure the best over-all results.

Before you buy a boiler, investigate the improved designs of C-E Boilers and the qualifications of this company to give you the kind of an installation that will measure up to all expectations.

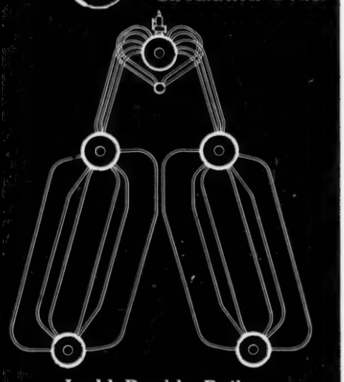
A General Condensed Catalog describing C-E Boilers will be sent upon request.

COMBUSTION ENGINEERING CORPORATION

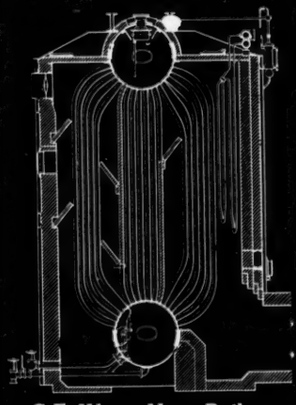
200 Madison Ave., New York



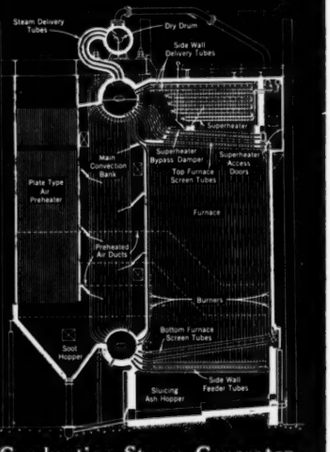
C-E Multiple
Circulation Boiler



Ladd Double Boiler



C-E Waste-Heat Boiler



Combustion Steam Generator

COMBUSTION

VOLUME FOUR • NUMBER TEN

CONTENTS FOR APRIL 1933

FEATURE ARTICLES

The Kelvin Temperature Scale	*by Joseph Keenan*	5
Slime and Mussel Control in Surface Condensers and Circulating Water Tunnels	*by Sheppard T. Powell*	7
Mechanical Draft Fans	*by M. S. Kice*	14
Patents, *Part 9*	*by George Ramsey*	21
The Selection of Stokers	*by John Van Brunt*	28
Steam Releasing Surface, or Steam Releasing Space?	*by Dr. Ing H. Vorkauf*	32

EDITORIALS

Costly Maintenance	6
Fan Development and Research	6
Stokers or Pulverized Fuel Equipment	6

DEPARTMENTS

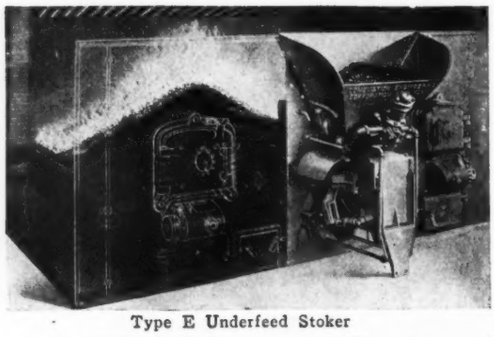
New Equipment—*Flexible Coupling, Portable Vibrometer, Recorder Case, Single Suction Self-Priming Pump, Portable Manhole Blower is Engine Driven, New Plastic Masonry Mortar, Underfeed Stokers, Portable Draft Gage, Feed Water Regulator*	34
New Catalogs and Bulletins	36
Review of New Technical Books	37
Equipment Sales—*Boiler, Stoker and Pulverized Fuel*	39
Advertisers in this Issue	39

H. STUART ACHESON, *General Representative* — CHARLES McDONOUGH, *Editor* — F. H. ROSENCRANTS, *Associate Editor*

COMBUSTION is published monthly by In-Ce-Co Publishing Corporation, a subsidiary of International Combustion Engineering Corporation, 200 Madison Avenue, New York. London office, Aldwych House, Aldwych, W.C.2. W. R. Wood, President; George H. Hansel, Secretary; W. I. Branigan, Treasurer.

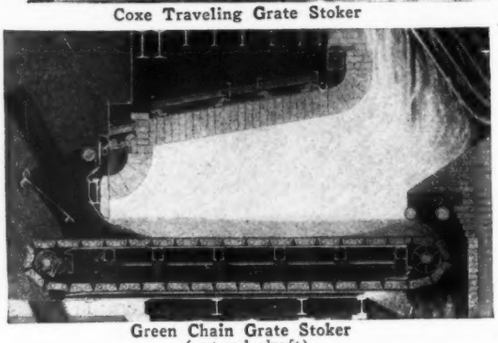
SUBSCRIPTIONS, including postage, United States, $2.00, Great Britain, £2.50 a Year. Canada $3.00 (includes Canadian tax). Other countries, $3.00. Single copies: 25 cents.

COPYRIGHT, 1933, by In-Ce-Co Publishing Corporation, New York. Printed in U.S.A. Publication office, 200 Madison Avenue, New York.



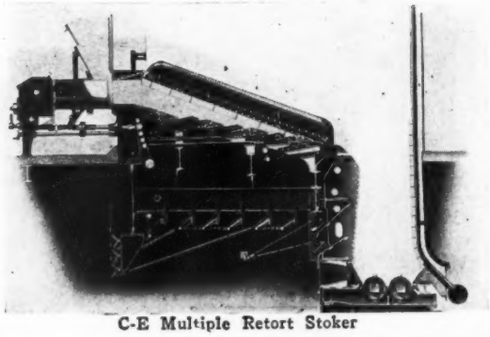
Type E Underfeed Stoker

Coxe Traveling Grate Stoker

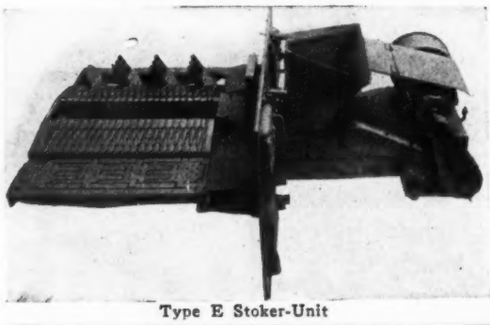


Green Chain Grate Stoker
(natural draft)

Green Chain Grate Stoker
(forced draft)



C-E Multiple Retort Stoker



Type E Stoker-Unit

STOKERS

All Types
All Sizes
For All Coals

The names, Type E, Coxe and Green, today, as for many years past, are synonymous with leadership in the stoker field. Viewed from the standpoints of engineering recognition, number of stokers installed or amount of boiler surface equipped, each of these stokers dominates its class.

In addition to these three stokers, Combustion Engineering Corporation manufactures the several other types illustrated on this page. The newest member of the family is the Type E Stoker-Unit for boilers in the approximate range of 40 to 150 hp. This stoker, modeled after its famous forbear—the Type E Stoker— is introducing new standards of performance in the small stoker field. Also illustrated is the C-E Multiple Retort Stoker, six of which were recently purchased for the new Federal Government Heating Plant, the contract being the largest for stokers awarded in 1932.

When you buy a stoker, *consider these facts:*

—Combustion Engineering Corporation has installed over 14,000 stokers in this country alone. (Several thousand more have been installed by associated companies abroad.)

—a large percentage of its total business is made up of repeat orders.

—its experience embraces all conditions of operation, all kinds of coal and all types and sizes of stokers.

You can depend upon it that any stoker sold by this organization will be of a type suitable for your fuel and operating conditions, will be built to give many years of reliable service with minimum operating and maintenance charges, will be properly installed, and will meet all performance guarantees.

COMBUSTION ENGINEERING CORPORATION

200 MADISON AVENUE NEW YORK

Commentary by Joseph H. Keenan

The Kelvin Temperature Scale

Let us assume for the moment that we can build a Carnot engine and set it to work taking heat from a large reservoir of boiling water and rejecting heat to a large reservoir of melting ice. For every one hundred units of work our engine turns out we shall find that 373 units of heat are taken from the boiling water and 273 units of heat are rejected to the melting ice. These heat quantities are the temperatures of the hot and cold reservoirs on the Kelvin scale, and the heat engine is a Kelvin thermometer. Any other temperature, say the freezing point of mercury, could be measured by rejecting heat from the engine to that temperature level. The number of heat units rejected for every 373 units added from the boiling water reservoir is the absolute temperature of the new level. Lower and lower levels might be sought yielding less and less heat rejection for our 373 units added until a level is reached at which no heat would be rejected and all the heat added would reappear as delivered work. This is the absolute zero of temperature. Had Prince Lucifer carried a Kelvin thermometer into those

"wider zones that pricked his scars
With memory of the old revolt from Awe",

he would have found it registering zero degrees Kelvin or 273 degrees below the centigrade zero. The ultimate of all coldness can be represented on the Centigrade scale by a negative number of no unusual magnitude.

Another type of Kelvin thermometer can be made if a gas can be found with two specific characteristics: first, its temperature does not change as its volume increases during throttling; second, its pressure-volume product is constant with change in volume at constant temperature. If enough of this gas is confined at the melting temperature of ice so that its pressure-volume product changes exactly one hundred units when it is brought to the temperature of boiling water then its pressure-volume product at any temperature level is the absolute value of that temperature on the Kelvin scale. If the gas is maintained at constant volume its pressure vanishes when its temperature is lowered to absolute zero; if it is maintained at constant pressure its volume vanishes at absolute zero; that is, the gas itself vanishes. This second inference makes it appear unlikely that such a gas exists. Science has failed to find one.

We have devised two Kelvin thermometers, both of doubtful value. The reversible engine thermometer would work precisely with any fluid, but the construction of the thermometer is beyond human skill. The pressure-volume thermometer, on the other hand, could be built with relative ease, but the gas prescribed does not exist.

Fortunately, there is another, more practical way to measure Kelvin temperatures. All known gases approach as a limit the conditions prescribed for the fluid of the pressure-volume thermometer as their pressure approaches the absolute zero of pressure. It is entirely possible to measure the pressure-volume product of any gas at lower and lower pressures until the value of the product can be extrapolated with confidence to zero pressure. If we use just enough of the gas to make the difference between the extrapolated products at the freezing and boiling points of water exactly one hundred units, then the extrapolated product for that much gas at any temperature level is the absolute value of that temperature on the Kelvin scale. This is a practical and useful thermometer and it is from such thermometers that the Kelvin temperature of the ice point, 273.15 degrees, has been found.

It appears that the only legitimate thermometric fluid for a pressure-volume thermometer is a gas at zero pressure, a condition quite unattainable. In a skeptical moment one might ask whether the extrapolation method is valid. It is just possible, and in accord with the perversity of material things, that somewhere below the lowest pressure reached in our thermometer the characteristics of the gas veer in a manner wholly unpresaged by the measured values. The extrapolation method is valid nevertheless. From measurement to measurement as the pressure is lowered the behavior of the gas comes nearer and nearer the conditions prescribed for the fluid of the pressure-volume thermometer. If it continues in this course then at zero pressure it will satisfy the requirements for our thermometer and it will have pressure-volume products equal to the extrapolated values. If, on the other hand, the gas departs from the course of the extrapolation at a pressure less than the pressure of the lowest measurement, it can no longer be considered a satisfactory thermometric fluid at zero pressure. But the hypothetical gas represented by the extrapolated pressure-volume data is still satisfactory in every respect.

In any of its various forms the Kelvin scale thermometer, like the rabbit in a dog race, is just beyond reach; and the absolute zero of temperature is as far from actual realization as is the thermometer on which it is marked. But despite these two degrees of inaccessibility the number of Kelvin units between the temperature of melting ice and the absolute zero of temperature is known to a very creditable precision. The remaining uncertainty is smaller than one part in ten thousand.

Joseph H. Keenan

Stevens Institute of Technology

EDITORIAL

Costly Maintenance

FAILURE to maintain at least a moderate stock of important repair parts for emergency replacements is certain to result in serious losses. Simple and axiomatic as this seems, the policy of waiting to order spare parts until a breakdown occurs appears to be quite widespread. In a recent editorial we told of the case of a manufacturer who incurred a heavy penalty on an important order because a tube in his high-pressure boiler ruptured and no spare tubes were on hand. More recently we have heard that manufacturers are receiving rush orders by telegram and long distance telephone to ship heavy parts to distant points by express. Within the past few days an equipment manufacturer told us that he had made three such shipments in a single week.

While in a few instances the losses due to this practice may not exceed the extra costs of express shipments and other attendant charges of a rush order, it is quite apparent that in the majority of cases heavy losses are inevitable. Where equipment vitally necessary to plant operation breaks down and cannot be immediately repaired, the loss of production time may run into startling figures.

It is common knowledge that many manufacturers have been dismantling some of their equipment in order to provide the necessary repair parts to keep similar units in operation. As a result they have only sufficient capacity to keep going on their present reduced volume, and are facing the prospect of excessive overloading and consequent breakdown at the first demand for increased production.

Engineers in charge of the operation of equipment that is not being kept in a proper state of repair and for which a stock of important spare parts is not being maintained owe it to themselves to see to it that their managements are properly informed of the false economy inherent in such conditions. Delay in correcting such conditions is almost certain to result in serious losses and to be embarrassing to those responsible.

Fan Development and Research

THE recent announcement of a fan testing laboratory at Harvard Engineering School *(Combustion,* December, 1932) served to emphasize the importance of continued testing and research in this field. In the work already done at this laboratory some very useful data have been obtained which will influence fan design and fan performance guarantees.

The very considerable cost of power for forced and induced draft fan installations and the attendant problems of fan drives, maintenance, etc., make it highly important that those concerned with these problems keep themselves up-to-date on their various phases.

With this in mind *Combustion* has made arrangements for several articles relating to the general subjects of fans and draft. The first of these, "Mechanical Draft Fans," is published in this issue and covers the design, performance characteristics and fields of application of the three centrifugal type fans. Subsequent articles, all by different authors, will deal with fan maintenance, draft losses and draft measurement.

Stokers or Pulverized Fuel Equipment

AN article in this issue, "The Selection of Stokers," touches briefly on the relative fields of stokers and pulverized fuel equipment. Ever since pulverized fuel firing gained recognition as an efficient and practicable method of burning coal under boilers, there has been much controversy and difference of opinion concerning its merits as compared with stoker firing. Obviously, the question is, and long has been, one that lends itself to definite engineering analysis. Nevertheless, a great many boilers have been equipped for pulverized fuel firing which could have been more economically and satisfactorily fired with stokers, and to a lesser degree. the opposite has been true.

The idea of pulverized fuel firing has an appeal which many engineers contemplating a new installation or a modernization program find it difficult to resist, and as a consequence the manufacturer of pulverized fuel equipment has had a certain psychological advantage. In many instances this has introduced a rather difficult question of ethics for those manufacturers of both stokers and pulverized fuel equipment who are more interested in maintaining their engineering reputations than in making an immediate sale.

Of course, where the relative advantages and disadvantages of both methods about balance off so that there is no substantial reason for advocating one or the other, it is undoubtedly the part of good salesmanship to follow along the line of least resistance and make recommendations in accordance with the buyer's preference. However, there are many instances, especially in connection with boilers ranging from 300 to 1000 hp., where stoker equipment would make a much better installation from every standpoint, and in such cases the conscientious manufacturer of both stokers and pulverized fuel equipment finds himself in a very difficult dilemma. If he is persistent in committing himself along the lines indicated by his engineering judgment and experience, he is likely to antagonize the buyer and jeopardize whatever chances he has of making a sale.

There will probably be fewer misapplications of stokers or pulverized fuel equipment now that we are in a period when practically all buyers must cast their prejudices and preferences aside and be guided only by sound engineering and sound economics. The lessons gained from past experience, in so far as human nature will permit itself to admit its own errors, should also serve as a corrective influence in such situations.

Slime and Mussel Control in Surface Condensers and Circulating Water Tunnels

By SHEPPARD T. POWELL

Consulting Chemical Engineer,
Baltimore

This is the first in the series of articles by Mr. Powell which we announced last month. In this article, the author reviews development in the prevention of slime and mussel growths by heat, chemicals and electrolytic processes and presents a comprehensive discussion of current practice. Each method is fully considered and its degree of success indicated in so far as results obtained up to the present time permit.

THE maintenance of clean condenser tube surfaces and intake circulating water tunnels is a problem of major importance in practically all steam generating stations where such equipment is used. The magnitude of this problem depends upon a number of factors, geographical location and quality of circulating water being of principal importance. Where circulating water is obtained from fresh water supplies, the problem will generally be limited to slime deposits on the condenser tubes only, but the use of salt or brackish water introduces additional difficulties from seaweed and crustacean growths. Such operating difficulties may be greatly magnified by sewage and trade waste contamination of the cooling water supply. Any deposits laid down on the tube walls reduce the heat transfer from the steam through the tubes into the circulating water, thereby lowering the overall efficiency of the unit, due to incomplete steam condensation. Condenser tube deposits are usually complex organic and inorganic substances, the composition of which varies greatly in different sections. Such "slimes" have a low heat transfer and when the deposits become sufficiently thick the condenser efficiency becomes so impaired as to require shutting down the unit and cleaning the tube surfaces mechanically.

It is rather surprising that these operating difficulties, until recently, have received so little scientific study. It is only within the past ten years that progress along these lines has been made and this has been accomplished largely through the intelligent effort of a group interested in the manufacture of slime control apparatus and working in cooperation with central station operators. One of the earliest and most comprehensive investigations was made by James Ritchie[1] in 1920. The study was inaugurated to determine the most practical method for controlling mussels in intake tunnels, but slime control in condensers was not investigated. About the same time, however, chlorination for the prevention of slimes was undertaken at the Borough of Hackney Electricity Station, London, England. Chlorination was practiced in co-operation with the Patterson Engineering Company, Ltd. and consisted of applying, continuously to the circulating water, chlorine at a rate of one-half to one part per million parts of water. This experiment was so successful, that the process was installed at many other stations. To date, chlorination of condenser water is practiced at nearly one hundred stations in Great Britain alone.

Slime removal by chlorine has advanced fairly rapidly within the last two or three years in this country. This is indicated by reference to Fig. 1. By the first of this year there were thirty-one central stations employing the intermittent de-sliming process and a number of others were utilizing bleaching powder or applying chlorine in other ways.

Composition of Condenser Tube Deposits

The character of slime deposits varies greatly at different stations and definite classification is difficult. Such deposits are usually complex mixtures and consist of one or more of the following materials:

1.—Hard scale, composed of calcium or magnesium carbonate, sulphate or silicate. Deposits of this kind are due to the deposition of mineral salts from very hard natural waters or in rare cases from sea water or water highly contaminated by trade wastes. This type of deposit is usually contaminated with organic matter, is extremely hard and difficult to remove from tubes.

2.—Gelatinous slimes are the most frequently encountered deposits. These substances adhere to tube surfaces and are not removed by velocities of water generally used in practical condenser operation. Deposits of this kind may be iron and aluminum hydroxide, oil, organic matter or aquatic plants or animals. Microscopic organisms play an important part in slime

[1] Report on the Prevention of the Growths of Mussels in Submarine Shafts and Tunnels at Westbank Electric Station, Portobello—Transactions Royal Scottish Society of Arts, Volume XIX, 1927.

formation, since they bind other materials together which would otherwise accumulate slowly, or be washed off the tube surfaces. Vegetable conglomerated slimes of this type may foul condensers rapidly, the rate of growth depending upon biological activity.

De-Sliming By Chlorine

Removal of condenser tube deposits by chlorine, commonly termed "de-sliming", is actually a process of sterilization. Chlorine is highly toxic to bacteria and other microscopic organisms and the destruction of these growths prevents the adherence of the suspended solids to the tubes under the usual water velocities in condenser operation practice. Where the water is re-circulated, continuous application of chlorine builds up a residual chlorine in solution so that chlorine is always present in the supply by the addition of minor doses of chlorine. Slime removal can be effectively accomplished in this way. At many plants, however, the circulating water is not reclaimed, so that complete chlorination requires larger amounts of the chemical to react with the organic matter carried by the water and still leave a residual in the supply. Under these conditions, especially at locations where the organic matter in the water is high, the cost of chlorine required for continuous treatment is prohibitory. It has been demonstrated, however, that chlorine applied in sterilizing concentrations over short periods is as effective as the continuous application of sterilizing concentrations. As a result of this discovery, de-sliming, by means of chlorine, has been developed into a practical and economical control procedure. The amount of chlorine and the frequency of application required to effect proper de-sliming, is a function of a number of factors but depends primarily on the degree of organic pollution of the water, dissolved gases and certain inorganic solids. Temperature also plays a part in the proper control of the treatment. In order that there may be sufficient quantities of the chemical to destroy microscopic life, it is necessary that slight excesses of chlorine be used over that required to react with the organic and inorganic constituents of the water. No specific dosage of chlorine, applicable for all conditions, can be established, since each water supply presents a problem in itself. Usually, however, the amount of chlorine necessary to effect proper de-sliming when using the intermittent method of application, will be between 0.4 and 5.0 parts per million. In rare cases, the dosage may be as high as 8.0 to 10.0 parts per million.

The amount of residual chlorine (excessive chlorine over that required for immediate oxidation of organic matter) necessary to de-slime condensers will vary greatly and is a function of the local operating conditions and the character of the circulating water. Under ordinary conditions the minimum residual would be 0.05 parts per million and the maximum 2.0 parts per million.

Since the character of water determines the amount of chlorine required to produce the desired results, this influences the frequency of dosage. In some cases the chlorine may be applied as frequently as once in thirty minutes or as long as once in three or four hours.

The Wallace & Tiernan chlorine de-sliming apparatus, is an adaption of similar equipment used for

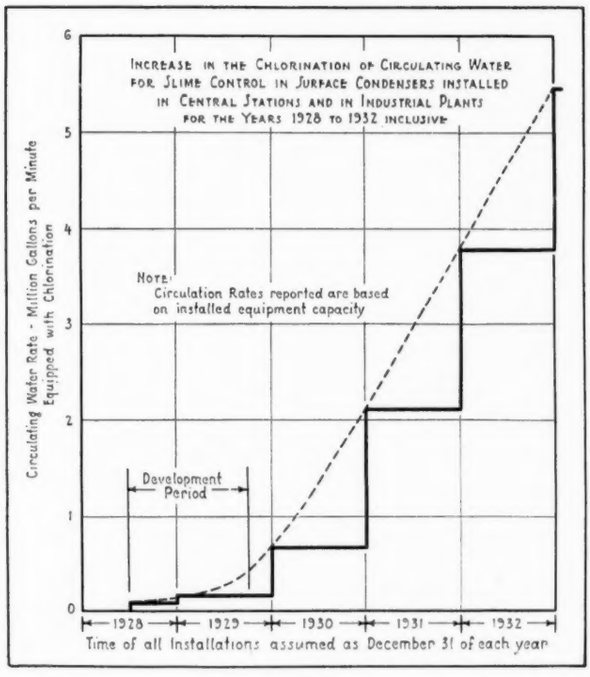

Increase in the Chlorination of Circulating Water for Slime Control in Surface Condensers installed in Central Stations and in Industrial Plants for the Years 1928 to 1932 inclusive
Circulating Water Rate - Million Gallons per Minute Equipped with Chlorination
Note: Circulation Rates reported are based on installed equipment capacity
Development Period
0
1
2
3
4
5
6
1928
1929
1930
1931
1932
Time of all Installations assumed as December 31 of each year

Figure 1

water and sewage sterilization, but necessarily a more elaborate design, since the process requires automatic and intermittent application of the chlorine solutions. There are two general designs which, operating on the same principle, differ from each other in respect to the method of applying the chlorine solution. The operation of the apparatus is relatively simple and requires little detailed attention or supervision. In the lime stone design, the chlorine gas is discharged from the chlorine containers to the vacuum type solution feed chlorinator, which is the control device for accurately measuring the chlorine. Chlorine solution is fed from this machine by means of a hose to a large wood tank filled with crushed limestone. This tank serves as a storage reservoir from which the solution is pumped into the circulating water at predetermined intervals of time. The operating cycles are regulated by a timing device. The frequency and duration of pumping the chlorine solution at each dosing period depends upon local conditions and is affected by water temperature and other controlling factors, requiring a greater or lesser amount of chemical to clean the tubes.

In the semi-automatic equipment, the chlorinator used is the same as that used in the limestone tower assembly. The chlorine solution, however is fed directly into the circulating water by gravity and no storage of the solution is provided. The chlorinators are entirely hydraulically operated and their operation is obtained automatically by means of motor-operated valves controlling the water supply to the chlorinators. The timing and the intervals of the dosage of chlorine are effected automatically by a program clock.

In certain instances if sufficient quantities of chlorine are used, slime deposits will be gradually removed even when the condensers are badly fouled. The best result will be accomplished however, when the condensers are thoroughly cleaned mechanically, prior to initial chlorination. The fairly extensive use of chlorine so-

lution for de-sliming of condensers and the data obtained from several years operation indicates that the process is entirely practical and where slime formation is rapid, the cost of operation and maintenance of the process can be justified by improved condenser performance. In most cases, mechanical cleaning of tubes has been entirely eliminated, while under severe conditions the period of condenser outage resulting from mechanical cleaning has been greatly reduced.

Continuous versus Intermittent Chlorination

The relative merits of these two means of chlorination has been debated, but there is no direct evidence that either system, when properly controlled and sufficient amounts of chlorine are used, is superior. The problem resolves itself into the efficacy of removal of living and dead organic matter and this in turn is a function of chlorine dosage. Further, there is no specific evidence that either form of treatment will result in corrosion, if the chlorine is properly applied and if excessive amounts of chemicals are avoided. In small installations, the fixed and operating cost required for intermittent treatment may be greater than for continuous treatment, owing to the larger investment required for the former type of plant. Where large quantities of water are to be chlorinated, however, the annual cost of the chemical consumed by continuous dosing may greatly exceed the fixed and operating charges for intermittent treatment. In the absence of specific data which justifies a preferential choice of either type of treatment, the adoption of either system must rest upon the net savings accruing from the specific treatment.

Chlorination of circulating water by means of hypochlorites has been practiced in this country but this form of treatment is limited. At one central station hypochlorite of lime (bleaching powder) was fed into the intake tunnel at intervals of once in six hours but the frequency of dosing was eventually raised to once every fifteen minutes. The chlorine applied by this method fluctuated from 0.10 to 0.50 parts per million at the inlet side of the condenser. This treatment, however, was found too expensive and was discontinued and replaced by automatic de-sliming equipment.

Mussel growths are particularly objectionable at this plant and although the chlorine treatment has been satisfactory for controlling deposits in the condenser tubes, the treatment has not been effective in eliminating mussels from the intake tunnels.

It is advantageous to have definite information concerning the chemical constituents and bacterial flora of the water which is to be chlorinated.

Cost of Treatment

The adoption of chlorine treatment for improving condenser operation will depend entirely upon local conditions, balancing the cost of treatment against the ultimate effects resulting therefrom. This in turn will depend upon the character of slime formed on the tubes and the increased periods between cleanings. In a recent study of fourteen installations of this type, the average saving for tube cleaning was twenty-eight man hours per week per condenser. The greatest saving from the treatment is the increased vacuum resulting from more efficient condenser performance. Records from ten companies have shown that the average increase in vacuum ranged between 0.15 to 1.5 inches Hg. It naturally follows that the greatest improvement occurred at plants where the heaviest organic growths occurred. Since the quantity of chlorine that will be consumed by water in a given time may vary from day to day, it is desirable to adjust the dosage of chlorine by frequent testing of the chlorinated water. The frequency of testing required varies at different places and the most satisfactory cycle of testing may only be established by experience under a given set of conditions.

The test for residual chlorine is extremely simple and can be made by station operators having no previous experience in making chemical analyses. In order to determine the required changes in treatment which will be necessary at different seasons chlorine absorption tests will be of value. This test is more elaborate and should be made by a trained analyst. The chlorine

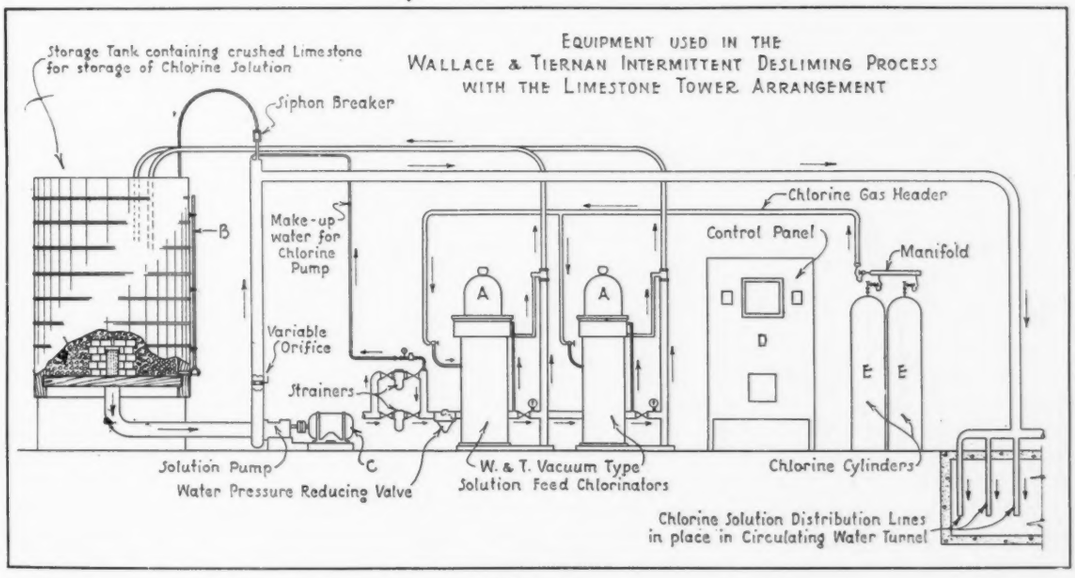


Figure 2

absorption test consists in treating a given amount of water with a standard chlorine solution and determining the amount of chlorine consumed by the water in a given period of time. Such control by the laboratory is desirable, since the absorption or destruction of chlorine applied to water varies greatly. The chlorine consumed by water is a function of the concentration of oxidizable materials in the water, the character of these substances, the temperature of the water and other factors. This latter recommended control should be supplementary to a routine control for residual chlorine. Procedure for making the tests for residual chlorine and chlorine absorbed is as follows:

Testing for Residual Chlorine

The reagent for the detection and estimation of chlorine is not only a specific test for chlorine but gives similar reactions with other constituents in water. Care must therefore be exercised in interpreting results. Nitrites and ferric compounds in large quantities, organic coloring matter, and chlorates are examples of interfering substances, which must be considered in evaluating results.

Reagents Required for the Test

(a) Ortho-tolidine solution. Dissolve one gram of ortho-tolidine in one liter of dilute hydrochloric acid (100 cc. concentrated acid diluted to one liter).

(b) Copper sulphate solution. Dissolve 1.5 grams of copper sulphate and one cc. of concentrated sulphuric acid in distilled water and make up to 100 cc.

(c) Potassium dichromate solution. Dissolve 0.025 grams of potassium dichromate and 0.1 cc. of concentrated sulphuric acid in distilled water and make up to 100 cc.

Procedure

Mix 1 cc. of the tolidine reagent with 100 cc. of the sample to be tested in a Nessler tube and allow the solution to stand at least five minutes. Small amounts of residual chlorine give a yellow color and large amounts give an orange color. For quantitative estimation, compare the color developed with that of standards in similar tubes prepared from the solutions of copper sulphate and potassium dichromate as indicated in the following table:

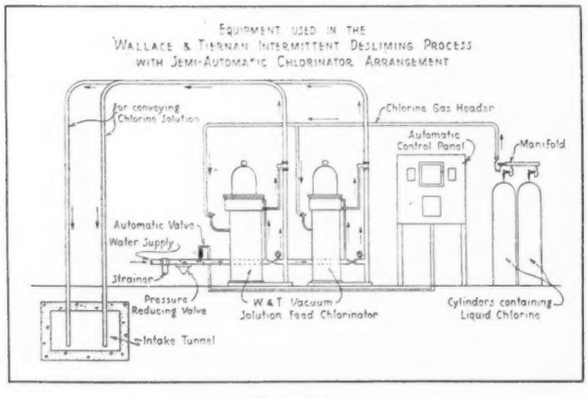


Figure 3

PREPARATION OF PERMANENT STANDARD FOR CONTENT OF CHLORINE*

CHLORINE	SOLUTION OF COPPER SULPHATE	SOLUTION OF POTASSIUM DICHOMATE
Parts per million	ml.	ml.
0.01	0.0	0.8
.02	.0	2.1
.03	.0	3.2
.04	.0	4.3
.05	.4	5.5
.06	.8	6.6
.07	1.2	7.5
.08	1.5	8.2
.09	1.7	9.0
.10	1.8	10.0
.20	1.9	20.0
.25	1.9	25.0
.30	1.9	30.0
.35	1.9	34.0
.40	2.0	38.0
.50	2.0	45.0
.60	2.0	51.0
.70	2.0	58.0
.80	2.0	63.0
.90	2.0	67.0
1.00	2.0	72.0

* Standard Methods of Water Analysis—Seventh Edition—1933.

Aquatic Growths Occurring In Circulating Water Tunnels

There is little accurate scientific data on the nature and life cycle of aquatic growths occurring in condenser intake tunnels, and this problem offers an interesting and fertile field for biological study. Although numerous species of aquatic plants and animals thrive in such conduits, mussels, due to their rapid rate of multiplication, greatly predominate over all other forms of life. Mussels are responsible for most of the difficulties resulting from clogging and restricting flows of water. The trouble is limited to stations using salt or brackish water. It is obviously impossible to prevent seeding of intake tunnels with mussel spats, owing to their minute size, and effective control measures must depend upon killing the young mussels before any appreciable accumulation occurs.

Slimes and similar deposits may occur in intake tunnels without causing serious difficulty, since ordinarily they do not become sufficiently thick to materially reduce the capacity of these conduits. The most serious trouble from such deposits results from sluffing off the tunnel walls and depositing on the condenser. These troubles, when experienced at all, are infrequent and are not major problems at most stations.

Effective control or elimination of mussel growths from intake tunnels requires a knowledge of the life cycle of these organisms. In general, mussels are similar to clams and other shellfish of the same species. The adult organism is enclosed in a relatively hard shell, consisting of an upper and lower half, which is hinged at the back, so that when the shells are closed the soft vital parts of the organisms are completely protected. Under ordinary conditions, the shell opens in order to permit feeding. This is accomplished by propelling a current of water into the shell by means of oscillating cilia, minute hair like protoplasmic projections, which move constantly in one direction. The water entering the shells pass to the inside cavity and gills and microscopic organisms, carried by the water, are consumed by the mussel and the undesirable suspended solids are rejected. This process of feeding is known as

drinking. To destroy mussels requires, therefore, that the chemical or other agent used must be brought into contact with the vital parts of the organisms.

As the young mussels develop from the egg stage they are about one hundredth of an inch and are free swimming. These minute organisms are borne along with the water and pass to and fro with the tide. It is obvious, therefore, that in waters where mussels are prolific, large quantities will be drawn into intake tunnels and be deposited therein, or elsewhere throughout the system. These minute organisms, while in the larvae state, will not cause damage. As they increase in size, however, they fasten themselves to stationary objects and it is in this condition that they cause clogging of pipes, conduits or tubes. The adult mussel will fasten itself, by means of a slender hair-like thread called the byssus, to any object submerged in water. Such growths may become sufficiently thick to block or at least greatly restrict the flow of water in the largest of intake tunnels. It is essential that any chemical treatment for the destruction of these organisms must be highly toxic and so applied as to be brought into direct contact with the vital parts of the by-valve.

Numerous chemical treatments have been considered and tried out either as measures for prevention of the growths or for destruction of the living organisms. The toxic effect of sulphuric acid has been studied, and when used in sufficient concentrations, will destroy these growths. In a few cases this treatment has been used successfully for cleaning small conduits. The concentration of acid required, however, is relatively high and the time of contact is much longer than would be expected. Concentrations of as high as one part of acid in 10,000 parts of water failed to completely destroy test specimens after 192 hours of contact. Higher doses of acid, however, are highly effective for killing growths. Aside from the cost of the treatment, high doses of acid, even when used at infrequent intervals, would be objectionable on account of the corrosion of metal or the tendency towards disintegration of concrete. The only time acid treatment should be used is in an emergency to clean out small pipes and where other correcting treatment is impractical.

Copper Sulphate Treatment

The investigation of Moore and Kellerman[1], 1904 and 1905 definitely established the fact that copper sulphate in relatively small doses was highly toxic to aquatic plants and animal life. This chemical has been used extensively for the control of algae and similar micro-organisms in water supplies. It is a natural sequence, therefore, that it should have been given consideration for the control of slime and other growths in intake tunnels and condensers. The dose of copper sulphate required to kill various types of organisms will range from one part per 100,000 parts of water to one part per 10,000,000 parts of water. If used in sufficient quantities, it will destroy algae and similar micro-organisms but is not as practical a method as chlorine and is objectionable, since it is an acid salt and, therefore, increases the corrosive properties of

[1] George T. Moore and Karl F. Kellerman, U. S. Department of Agriculture, Bulletins No. 64 and 75, 1904 and 1905.

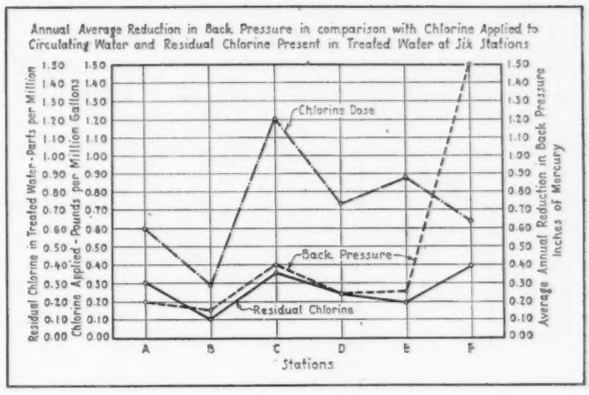

Annual Average Reduction in Back Pressure in comparison with Chlorine Applied to Circulating Water and Residual Chlorine Present in Treated Water at Jik Stations
Residual Chlorine in Treated Water - Parts per Million
Chlorine Applied - Pounds per Million Gallons
Average Annual Reduction in Back Pressure Inches of Mercury
Chlorine Dose
Back Pressure
Residual Chlorine
A
B
C
D
E
F
Stations

Figure 4

water when used in very heavy doses (one part in 10,000 parts of water). It will destroy young mussels but is not very effective against full grown organisms. The writer used this treatment with fair success a few years ago as an emergency treatment to remove heavy vegetable growths from a large intake tunnel. The treatment was effective but costly and resulted in a fairly high loss of condenser tubes. Copper sulphate has a further disadvantage, in that it does not oxidize organic matter and the products of reaction may, and actually have accelerated tube corrosion due to deposits or film laid down on the metal. Now that the chlorination process for slime removal has been perfected it is doubtful if copper sulphate will again be used for de-sliming condensers or intake tunnels.

Effect of Elevated Temperatures on Aquatic Organisms

One of the most effective methods for killing mussels is to raise the temperature of the water, since this species of crustacea cannot survive in water at temperatures of 106 fahr. or higher. In the experiments conducted by Ritchie, raising the water gradually from 60 to 106 fahr. killed all organisms in 22 minutes. At 104 fahr., however, the larger organisms survived while the younger ones were destroyed. Mussels were not killed in four hours at 84 fahr. but were completely destroyed at this same temperature at the end of fourteen hours. Ritchie's conclusions were that these growths could be completely destroyed at 90 fahr. if the temperature was maintained for several hours, or at 110 fahr. in a short time.

In most cases, increasing the temperature of the water in the discharge tunnels is easily accomplished but it is much more difficult to regulate the temperature of the water in the intake tunnels. At the Portobello Station, London, this difficulty was overcome by arranging the openings of the valves on land shafts in such a way that a portion of the water was repumped a second time. This had the immediate effect of raising the temperature of the water and loosening a large quantity of mussel growths from the walls of the tunnel. This procedure is not ideal, since the dead mussels are carried along and may lodge in the water boxes or in the condenser tubes. In some cases these growths have been destroyed by periodically admitting steam into the circulating water in the condenser with the inlet sluice valve closed and by so doing backing

hot water into the suction pipe. This treatment is also open to the same criticism of fouling the water boxes and tubes with dead mussels. An ideal method of eliminating mussel growths from intake tunnels would be to have a by-pass discharge line around the condenser. If this were done and the mussel killed by raising the temperature of the water, dead organisms could be readily flushed out of the system without danger of clogging the condensers.

Although the destruction of mussel growths by raising the temperature of the water is highly effective, this treatment will not remove slime or keep condenser tubes clean. Thermal treatment is worthy of consideration, however, owing to the rapidity at which the mussel can be killed by moderately elevating the temperature of the water. The difficulty, however, is the removal from the intake tunnel of the dead mussels. Some attempts have been made to remove slimes in condensers by cooking or baking them with a judicious introduction of steam into the steam space with the water space empty. While this treatment accomplishes the purpose of drying out the slimes which can be sloughed off in flakes when the circulating water is again applied, trouble may be experienced due to the development of leaks caused by excessive expansion of the tubes and possibly, also, to drying out tube packing.

In at least one station in this country, removal of growths from condenser tubes is effected by air drying but this has not been particularly satisfactory. Others have used acid and have reported that cleaning with hypochloric acid, if done infrequently and under proper supervision, causes no appreciable deterioration of the tubes. This form of treatment, however, may be subject to criticism since, unless done with extreme care, it may cause serious damage to the condenser and constitute industrial hazards to the workers.

Opinions of investigators differ greatly in respect to the efficacy of chlorine treatment for destruction of mussels. A number of observers in Great Britain, France and India have given evidence that chlorination is an entirely satisfactory control procedure for eliminating mussels from intake tunnels. Experience

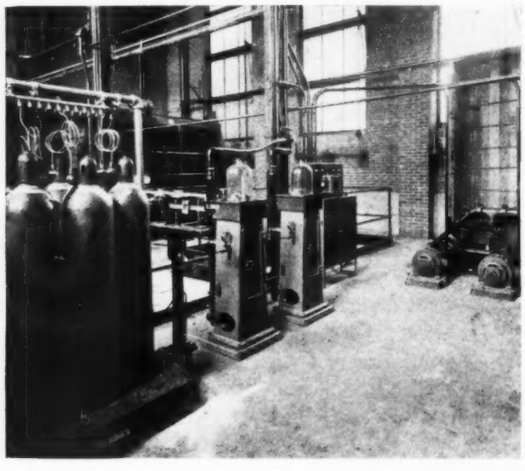


Fig. 5—Typical installation using the W & T intermittent desliming process showing chlorinators, solution tank, pumps and control apparatus.

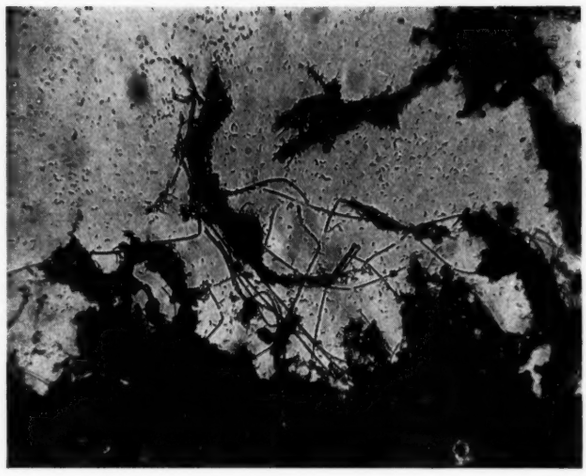


Fig. 6—Micro-photograph of a typical microscopic field of accumulation taken from condenser tubes. (magnification approximately 5000 dia.)

in this country is quite contrary to that reported abroad. The species of mussels found in the Atlantic Ocean are the same here as in England and France, so that the different toxic effects noted would indicate that these differences may be tracable to the degree of toxicity of chlorine on these organisms under continuous or intermittent doses. The life cycle of these crustacea and their normal environmental existence would justify these assumptions.

It is a well known fact that oysters, mussels and other bivalves can exist with their shells closed for days and are only forced to open their shell to obtain a supply of oxygen necessary for life. It has been demonstrated, also, that adult oysters and also mussels can survive for an appreciable length of time in water containing small amounts of residual chlorine. This condition does not hold for mussels in the egg stage or for young "spats." It follows, therefore, that intermittent chlorination would not be effective in destroying mussels, owing to the short period the organisms are in contact with the chlorinated water, since during the dosing period their shell can be kept closed without apparent injury. Under conditions of continuous chlorination and when appreciable quantities of chlorine are present, the organisms must be subjected to the toxic effect of the chlorinated water whenever they open their shell for feeding. There is a dearth of accurate data on the toxic effect of chlorine on mussels so that scientific proof on this supposition is lacking. It is difficult, however, to account for the difference in the reported toxic effect of chlorine treatment on mussels in this country and in European practice, except that slime control abroad has been largely by continuous application of chlorine to the circulating condenser water, while in this country the intermittent method predominates.

Removal of Mussels Manually

In large tunnels, scraping mussels from the walls of the tunnels and shafts is a dangerous and costly operation, but in the past has been necessary where prolific growths of these organisms have occurred. This operation, of course, requires taking the tunnel out of

service and draining it and removing the deposits after they have been scraped from the surface. In small intake pipes and conduits, removing the mussels is not a difficult problem. Iron balls have been used, discharging the balls through the tunnel under water pressure. A more effective and practical method would be to utilize a pipe cleaning rotary cutter termed a "go devil." This type of apparatus will remove deposits from the walls of pipes up to 48 in. in diameter or greater.

Electrolytic System

The electrolytic prevention of slime and other deposits has been practiced for a number of years but this control procedure has been limited to a relatively few plants. The process is based upon the theory that corrosion of condenser tubes and slime deposits upon metal surfaces are retarded when the tubes are maintained in a cathodic state. This condition is effected by an electromotive force applied externally through the condenser or other equipment requiring protection. Credit for this type of protection is generally given to Cumberland [1] who presented a detailed discussion of the process before the British Institute of Metals in 1916.[2] Since that time Kirkaldy [3] and others in this country have improved and patented many new de-

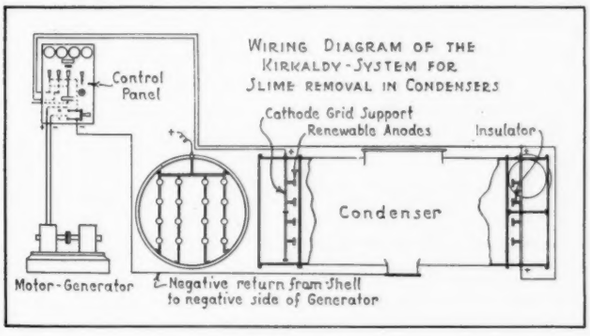


Figure 7

signs and a number of installations have been made for the protection of boilers and condensers. Although there has been much controversy over the efficacy of such protection, both in this country and in Great Britain, these processes have some merit as indicated by recent experiences. Operating data to justify their adaptability under all conditions, however, is still lacking.

The largest installation in this country was installed some years ago at The Long Beach Station Plant No. 2 of The Southern California Edison Company. Two condensers were originally equipped with the electrolytic protection system and similar equipment was installed on other condensers later. The process was installed primarily for inhibiting corrosion of condenser tubes. The apparatus as originally installed consisted of sixteen cast-iron insulated anodes placed against the tube sheets in each end of the condenser. Direct current is supplied to the anodes at from 6 to 10 volts from a motor generator set. The current density is from 2.5 to 5.0 amperes per 1000 sq. ft. of cooling surface. A typical installation is shown in Fig. 7.

It is reported that the apparatus has greatly inhibited rapid tube corrosion and has assisted in keeping down slime deposits, but de-sliming with chlorine is also used in addition at this station on the same units. Similar installations have been made at three steam stations in the East, but at these supplementary stations chlorine treatment is not used. Reductions of slime deposits and tube losses have been reported at the stations where condensers have been equipped with this type of apparatus. It is difficult to determine if slime control is effected wholly by the counter electromotive force or to what extent the chlorine generated by electrolysis of the salt water influences the condition. The amperage maintained is so low that it is unlikely that appreciable quantities of chlorine would be generated. One operator, however, reports that some chlorine is produced, indicated by the odor of the gas when the units are opened.

[1] "The Electrolytic Methods of Preventing Corrosion," Elliott Cumberland.
[2] Proceedings of the Annual Meeting of the British Institute of Metals, London, March 29, 1916.
[3] Alexander Kirkaldy. 508 Fifth Avenue, New York, N. Y.

Third Annual Economic Conference of Engineers

The Third Annual Session of the Economic Conference of Engineers will be held August 12 to 20, 1933, at the engineering camp of Stevens Institute of Technology, near Johnsonburg, N. J., in the hill country of northern New Jersey, within easy motoring distance of New York and Philadelphia.

The Economic Conference, initiated by Stevens Institute of Technology in 1931 and sponsored that year by engineering alumni of Stevens Institute and Columbia University, has established itself in two seasons as the annual forum for engineers interested in the study and free discussion of major current economic affairs. In the second season, 1932, engineering alumni associations of eight leading colleges associated themselves with the undertaking. After observing the workings of the Conference through two seasons, the American Society of Mechanical Engineers joins with other associations in recommending to its members that they attend the conference—for the full session if possible, or at least for the "week-end special" with which it will conclude.

The purpose of the conference is to bring the engineer up to date in current economic thought and to interpret to the general public his point of view. The sessions of last summer were reported at length in the metropolitan press.

The general program involves morning sessions of the seminar or classroom type, afternoons free for sports and recreation, and evening lectures by eminent authorities with discussion from the floor. The conference has been open on equal terms to right, center, and left-wing adherents.

In 1931 the general topic was *The Business Depression,* with morning sessions on *Corporation Finance.* The topic in 1932 was *Money and Banking.*

The general theme of this year's conference will be announced when events have made clear what it should be. A suggestion under consideration is *New Developments in Banking and Currency.*

Mechanical Draft Fans

By M. S. KICE
Asst. Chief Engineer
American Blower Corporation,
Detroit

The problem of selecting forced and induced draft fans for modern boiler installations involves the analysis of many factors. It is highly important that the fan equipment installed be of a type and size that are well suited to the operating conditions. The author analyzes this problem with respect to the three types of centrifugal fans. He discusses the performance characteristics of these fans and points out their advantages and limitations relative to various service requirements. He also discusses the related problems of fan drive and fan control. His treatment of the subject is thoroughly practical and should be of assistance to engineers concerned with the installation of mechanical draft equipment.

THE design of present-day, high-capacity steam generators with their accompanying economizers, air heaters, etc., has greatly increased the importance of forced- and induced-draft fan performance. Satisfactory fan performance in a particular installation will depend largely upon the intelligence exercised in making the installation. Stated briefly, the principal problems of fan installation are:

What type and size fans shall be selected?
How shall the fans be driven?
How will their air or gas output be controlled to balance fuel and air for all boiler ratings?

The reader is undoubtedly familiar with the three centrifugal fan types. The radial blade, called also the steel plate fan, is the oldest of the three. An example is shown in Fig. 1. A forward-curved blade fan is shown in Fig. 2, and the backwardly-inclined blade fan, called the high speed, also the non-overloading fan, is shown in Fig. 3. All three types have been used successfully by the writer for both forced-draft and induced-draft work, in single as well as parallel operation.

For high-pressure induced-draft work or where the gas stream contains abrasive, or carbon in case of some oil-fired boilers, the radial or the forward-curved blade fan, when properly selected, is equally good from an operating standpoint. The radial fan, however, despite a much higher wheel-tip speed, operates at a considerably lower shaft r.p.m. This is because the radial fan wheel is much greater in diameter for the same power.

For lower pressures, say up to about 6 in. static pressure, and where the gases are reasonably clean, the high speed also has been successful. It has the advantage of more practical shaft speed, especially where a large volume of gas is handled at only one or two inches as in the case of gas-fired boilers. The other types in this case would require back gears, chain or belt drive, or the driving unit would be excessively large.

The high-speed fan is well adapted to forced-draft work, especially when moving cold air. This fan not only can be designed for very high mechanical efficiency, but the peak of the mechanical efficiency curve occurs at a fairly low per cent of capacity which enables it to be very economical in power consumption, especially when driven by variable speed.

Multiple pulverized fuel burners, using forced-draft and taking secondary air from a wind box or a plenum chamber, are an application particularly suited to the high-speed fan. In this case, one or more burners of a battery are used, and each requires the same static pressure whether one or more are operating. This usually is somewhere around 10 in. static pressure. This condition, of course, requires constant-speed operation of the fan with damper control. Selecting the high-speed fan for this duty at low per cent capacity overcomes the excess damper losses that occur when it is picked at a higher per cent capacity.

The forward-curved fan has been successfully used for supplying forced draft, either cold or hot air, for stoker, pulverized fuel and gas-fired boilers. Hot air forced-draft fans require inlet boxes, and the bearings should be located outside the boxes. In the case of a high-speed fan, if the pressure is very high, this causes difficulty in designing the shaft and bearings, because the high r.p.m. of the high-speed fan allows a very slight shaft deflection, if the shaft is to be operated below the first critical speed—which operation is highly desirable for constant speed, and vitally necessary for variable fan speed. Very large shaft and bearings are required to accomplish this, but another difficulty follows. High r.p.m. and large bearing diameter compel very fast bearing and shaft rubbing speeds in case of babbitt bearings, and a worse condition of high roller revolutions in case of roller bearings. Both generate excessive heat, which should be avoided.

Contrasted to this condition, the forward-curved fan operates at about half the r.p.m., hence about four times the deflection is allowable which, in turn, allows the use of smaller diameter shaft and bearings.

The radial fan with engine drive has been used a great deal in the past for forced-draft in smaller plants, or in plants where exhaust steam is useful. However, the high-speed fan driven by a turbine is used more today, as it requires much less space.

Type Characteristics

One way to visualize the three types is to study what might be considered the optimum of each to produce pressure in single stage.

Each fan can be designed for a blade tip speed of about 24,000 ft. per min. without using very special metals and fabrication. At 70 fahr. and at this speed, the pressure each should produce when operating at the point of maximum mechanical efficiency is, radial—48 in., forward-curved—86 in. and high speed—24 in. static pressure. No forced-draft application has approached these limits, except for the high speed fan.

Induced draft at 450 fahr., when the gases are lighter, would change these pressures to, radial—28 in., forward-curved—50 in., high-speed—14 in. Thus there is still some reserve in induced-draft fan design to meet advancing air pressures.

Another way to size up the three fans is to determine what tip speed is required for a given pressure. Assume 16½ in., which has been specified several times the past few years. At the 450 fahr. gas temperature the tip speeds are radial—18,400, forward-curved—13,800 and high speed—26,100 ft. per min. As an induced draft fan, it is seen the forward-curved would be a choice because low wheel-tip speed is desirable, though the radial wheel-tip speed is not excessive. The high-speed fan operates too fast. Further along the radial and forward-curved will be studied in more detail.

Size of Fan

The type of fan selected will be also influenced somewhat when relative sizes are estimated. It is the fan duty that determines the size. For lack of a better yardstick to measure the size fan required, it may be said that that size is best which allows the fan to work the best. This statement seems too self-evident to be made but the point is that consideration is not always given as to just what makes a fan operate the best, especially when one gets confused about the so-called rising pressure characteristic.

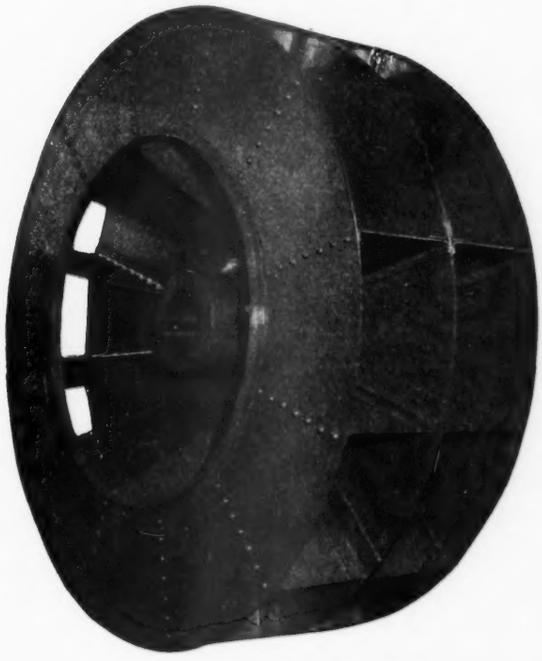


Fig. 1—Radial blade fan wheel.

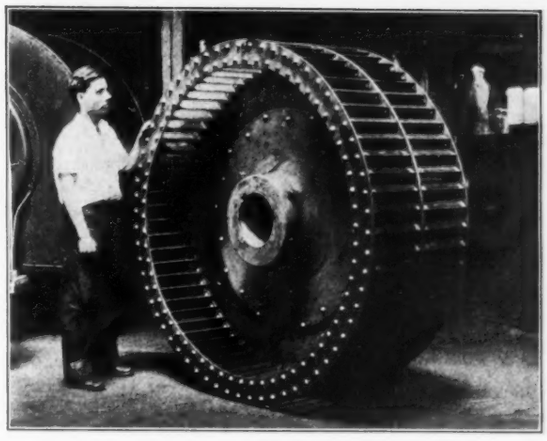


Fig. 2—Forward-curved blade fan wheel.

The experience of the author indicates the best place to pick the fan is at the peak of the mechanical efficiency curve, regardless of the type of pressure curve the fan possesses. At this point, the fan will put out maximum useful power for a given power input, hence it must waste less power with internal turbulence. If so, the air must be flowing through the fan in the smoothest fashion and must be more evenly distributed over the wheel blades. Hence, in the case of an induced-draft fan, moving abrasive gases, it is reasonable to believe there will be minimum wear, because wear is more evenly distributed and more of the material will pass out of the wheel between the blades without scrubbing them. Thus the volume and temperature of the gases, the static pressure and this point of maximum mechanical efficiency will establish one size of one type of fan for a given job. Another type of fan of course will be another size, in terms of wheel diameter. This is a good reason why care should be exercised in estimating the correct static pressure and temperature when the specifications are written.

The old method of estimating air, then pressure and then adding any arbitrary factor on both air and pressure for "safety" is not good practice. Whatever factor is added for volume should be added as the square or other proper exponent to the pressure. To whatever leakage volume factor is selected should be applied the proper pressure factor depending on where the leakage is considered to take place. The effect of the extra air on temperature should be considered. If all this is done with some care a proper selection will be made and the result will be a successfully operating job.

Sometimes it is not clear whether the pressure of an induced-draft fan is static (pure resistance pressure), or whether it is suction (total pressure). If the fan is selected on the basis of suction pressure, it will be rated at less speed and less power requirement than if the same pressure were figured as static pressure. Confusion exists perhaps because induced-draft fans induce or draw through, producing a negative pressure. However, it should be considered as plus, that is, so much above absolute pressure instead of so many inches below atmospheric pressure.

In one case, the writer was asked to deduct from a

specified static pressure, a stack draft of ½ in. Such stack draft should be ignored, because if the stack is strong enough to help the induced-draft fan, then the fan will not be needed.

Erosion

One very nice thing about the forced draft fan is that it doesn't need reblading, though if it could carry some of the load of the induced-draft fan, it would help its running mate not to scrub out. It can't do this, of course, because the combustion chamber is not designed to operate under pressure.

Erosion, abrasion or plain scrubbing, as it is called, takes place all along the path of the high-velocity fly ash, or cinder-laden air discharged from pulverized fuel burners and high-rating stokers. The induced-draft fan gets its share.

There are no commercial and practical metals or alloys that will resist this scouring action of the ash particles any better than plain cast iron or steel. One of the best tools to repair fan blades and housings is the arc welder; hence it is axiomatic that heat-treated alloys should not be used to build the induced-draft wheel, for the heat from the arc would destroy the required physical properties of such a treated alloy.

The most sensible way of minimizing erosion maintenance is to select the fan properly, as described, provide wearing plates where it will be attacked, and to operate the fan at variable speed so that when the boiler is operated at low ratings, the fan speed will be reduced with a corresponding reduction in wear and maintenance.

Wherever possible, the induced-draft fan should be of the double inlet type with the proper inlet boxes for the particular type of fan. This is to lower as much as possible the gas inlet velocity into the wheel so the abrasive particles can turn and pass evenly through the wheel instead of sand-blasting in a jet to strike the center-plate of the wheel. Rectangular inlet boxes do not require wearing liners any more than does any straight breeching, because the air stream does not have to rotate in the straight inlet box.

Fig. 3—High speed fan wheel.

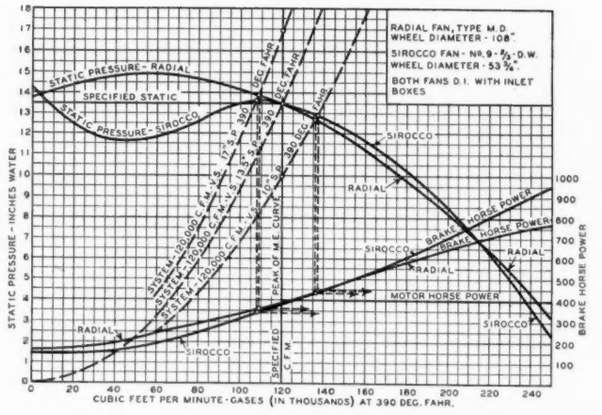

RADIAL FAN, TYPE M.D. WHEEL DIAMETER - 108".
SIROCCO FAN - NR. 9 - 2/3 D.W. WHEEL DIAMETER - 53¾".
BOTH FANS D.I. WITH INLET BOXES
STATIC PRESSURE - RADIAL
SPECIFIED STATIC
STATIC PRESSURE - SIROCCO
SYSTEM - 150,000 C.F.M. @ 17.5" S.P. @ 390 DEG. FAHR.
SYSTEM - 120,000 C.F.M. @ 13.5" S.P. @ 390 DEG. FAHR.
SYSTEM - 100,000 C.F.M. @ 10" S.P. @ 390 DEG. FAHR.
PEAK OF M.E. CURVE
SPECIFIED C.F.M.
SIROCCO
RADIAL
BRAKE HORSE POWER
MOTOR HORSE POWER
STATIC PRESSURE - INCHES WATER
BRAKE HORSE POWER
CUBIC FEET PER MINUTE - GASES (IN THOUSANDS) AT 390 DEG. FAHR.

Fig. 4—Test performance of 2 fans identified as radial and Sirocco. The former is a type M.D., wheel diameter 108 in. The latter is a No. 9 - 2/3 D.W., wheel diameter 53¾ in. Both fans of double inlet type with inlet boxes.

From an erosion standpoint, it would seem to the writer that it would be a desirable characteristic of the fan to have the peak of the static-pressure curve as near the peak of the mechanical-efficiency curve as possible. At the peak of the static-pressure curve, the fan's pressure producing capacity is satisfied; hence the air must bend more easily from the inlet, through the wheel. The fact that the mechanical-efficiency curve also is satisfied would indicate lack of blade re-entry and other losses. This is contrary to the theory of selecting a fan for "rising static" which was originated before erosion problems became so prominent. This is a great factor in favor of the forward-curved fan for induced-draft applications, for the other two types do not have this coincidental static pressure—mechanical efficiency satisfaction.

Fan Overload

As will be shown, the radial and forward-curved fan motor size can be selected close to the maximum fan power without danger of overloading if the pressure is not what it was estimated to be, or if it varies considerably. The introduction of the "non-overloading" high-speed fan has left an implication that the other two types do overload. When the fan characteristic curve is not properly interpreted, it does appear that a slight drop in the static pressure would call for a great deal more air and power. One fundamental principle, however, prevents this. Suppose any fan is operating at a speed to produce a given static head for a definite flow. In order for this to take place, the system to which it is connected must offer resistance to this flow equal to the fan's ability to force that flow through the system. Assume part of that resistance is removed. At once the fan is unbalanced, hence handles more air. However, as the fan handles more air, the resistance rises, say, as the square of the velocity increases. At the same time the fan's ability to maintain the previous static pressure diminishes because a greater part of the air energy becomes kinetic. The fan and the system come together at a new pressure and new volume where stability immediately takes place.

Thus, through the original volume abscissa, and the

lowered pressure ordinate, a curve is drawn as $y = x^2$, to intersect the fan pressure curve, and from that new volume abscissa, the proper ordinate of horsepower is read.

As an example, suppose a specification demands two induced-draft fans per boiler in parallel, each to deliver 120,000 c.f.m. against 13.5 in. static pressure, driven by a 60-cycle motor and the gas temperature for this maximum rating is 390 fahr. It is assumed the fan speed and power are to include losses in the inlet boxes from curves actually drawn from tests according to the code for testing fans of the American Society of Heating and Ventilating Engineers.

For this particular specification, Fig. 4 shows the actual test performance of two fans, either of which will give equally good service. The forward-curved fan is a Sirocco No. 9—2/3 D.W.—and the radial is a 108 in. M.D. fan, both double inlet with inlet boxes. The Sirocco operates at 850 r.p.m. and the M.D. operates at 575 r.p.m. They both take about the same power, but the M.D. fan takes up a great deal more space on the floor and above the floor, and requires a larger frame, driving motor and larger hydraulic coupling.

It is interesting to observe that if a 400 hp. motor is selected to drive either fan, which in this case requires about the same horsepower (Sirocco 380, M.D. 384), and if the system resistance for 120,000 c.f.m. at 390 fahr. drops about 25 per cent, or to 10 in. S.P., the motor with either fan will be overloaded only 10 per cent. And again, if for any reason the system resistance increases 3½ in. the volume will drop about 8 per cent and the power will drop about the same amount.

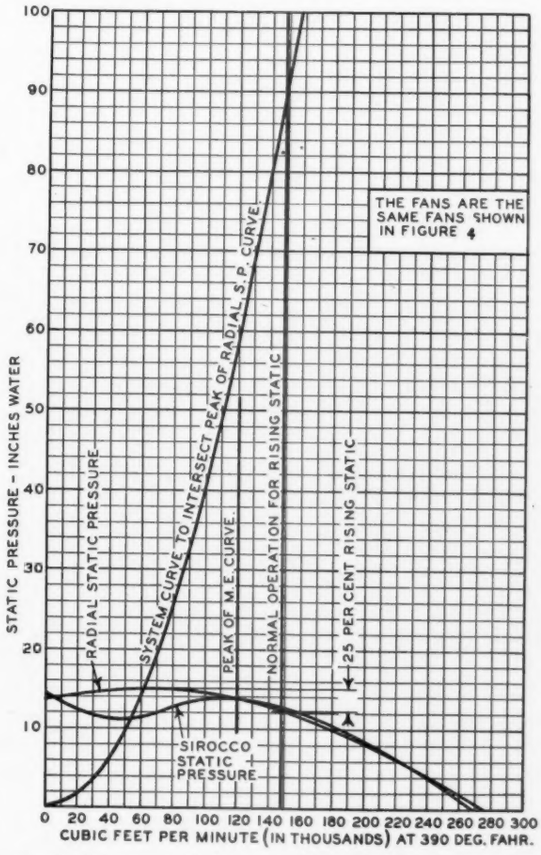

STATIC PRESSURE - INCHES WATER
100
90
80
70
60
50
40
30
20
10
THE FANS ARE THE SAME FANS SHOWN IN FIGURE 4
RADIAL STATIC PRESSURE
SYSTEM CURVE TO INTERSECT PEAK OF RADIAL S.P. CURVE
PEAK OF M.E. CURVE
NORMAL OPERATION FOR RISING STATIC
25 PER CENT RISING STATIC
SIROCCO STATIC + PRESSURE
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300
CUBIC FEET PER MINUTE (IN THOUSANDS) AT 390 DEG. FAHR.

Fig. 5—Performance of the same fans referred to in connection with Fig. 4 under conditions of rising static.

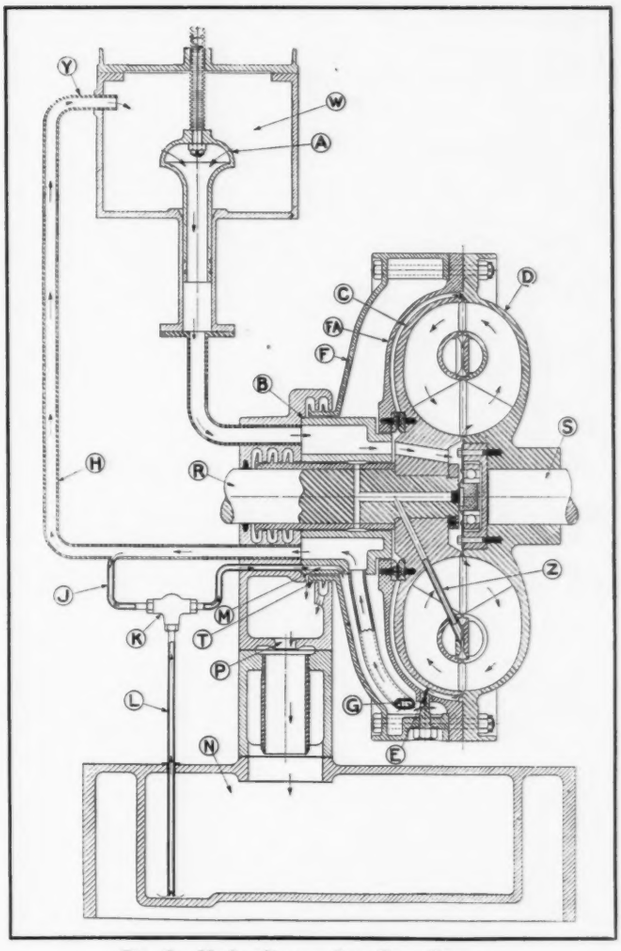


Fig. 6—Hydraulic coupling flow diagram.

The 400-hp. motor can operate at 20 per cent overload for two hours. This is 480 hp., at which rating either fan would deliver about 148,000 c.f.m. at 12 in. S.P. This is about 7.9 in. S.P. for 120,000 c.f.m. required to carry the boiler to maximum rating.

Although the motor was selected with only 5 per cent reserve capacity, and though the static for 120,000 c.f.m. dropped 42 per cent, the motor is not exceeding its maximum load carrying capacity. Actually this overload would reduce the motor speed a trifle, which in turn would relieve the overload to some extent.

Before the motor could be damaged from this condition, the air volume would have to be cut back to 120,000 c.f.m., or too much steam would be generated. Thus there is very ample allowance for static pressure miscalculation, without seriously overloading the motor. In this practical light, it is seen the necessity for a non-overloading fan is entirely academic.

Parallel Operation

This same reasoning illustrates how it is impossible for one fan of either type to "run away" from another fan in parallel. This parallel operation trouble simply does not happen, as is evidenced by a great many forward-curved and radial fans that are operating in parallel. For example, in one steel mill there are 14 Siroc-

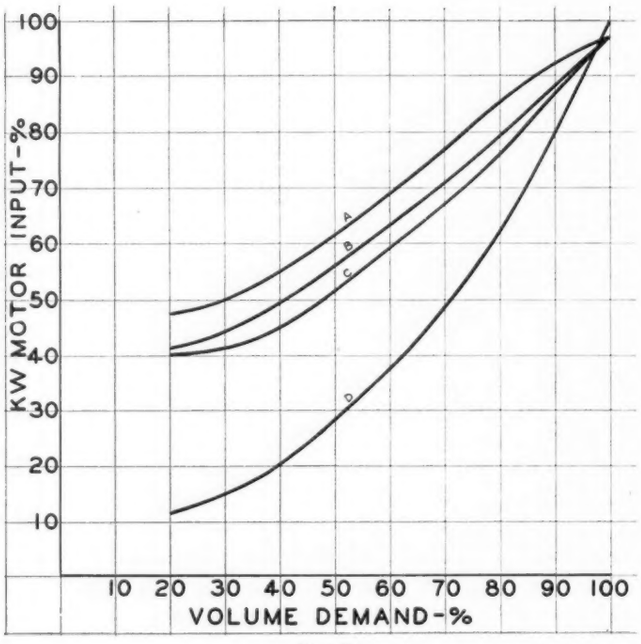


Fig. 7

Fan driven by single constant speed motor and hydraulic coupling compared with three types of fans driven by single constant speed motors and damper control, viz: A—High speed fan with backwardly inclined blades. B—Radial blade fan. C—Forward-curved blade fan. D—Any fan with hydraulic coupling drive.

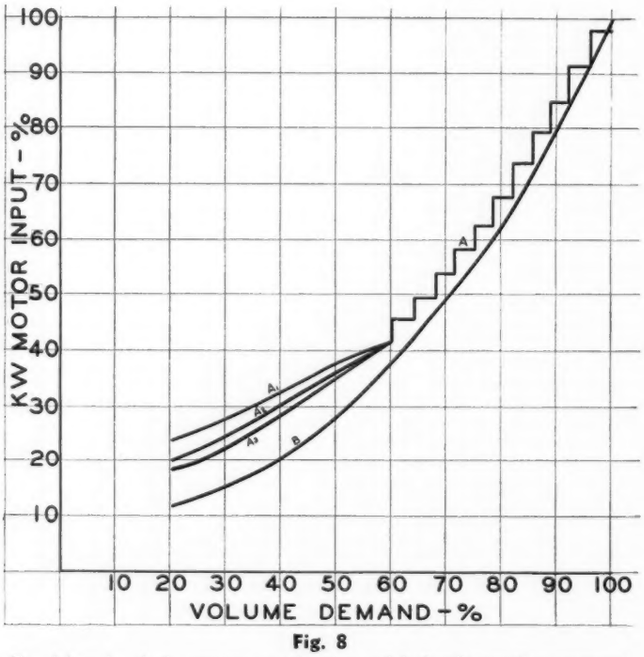


Fig. 8

Fan driven by single constant speed motor and hydraulic coupling compared with slip ring motor control without damper auxiliary control between steps but with damper control beyond low slip ring speed, viz: A—Eleven point slip ring control. A_1—Backwardly inclined blade fan with damper. A_2—Radial blade fan with damper. A_3—Forward curved blade fan with damper. B—Any type fan with hydraulic coupling drive.

co induced-draft fans working against 11½ in. S.P. at 600 fahr., each driven by separate slip-ring motors operated by automatic control, with common inlet boxes for each pair of fans and common stack connections—in fact, common stub stacks. The same steel mill installation also uses Sirocco forced-draft fans in parallel for the same boilers, each with individual drive and control. The majority of induced-draft fans the writer has designed are working in parallel in pairs.

Rising Static

Assume these same two fans referred to in connection with Fig. 4 are used for a duty that provides "rising static" on the performance curve. Suppose it is 148,000 c.f.m.—12 in. S.P. 390 fahr. —480 b.hp.—and that the radial fan is operating at 575 r.p.m. The Sirocco fan performs about the same, except at 850 r.p.m. The problem is, if the static for some cause becomes greater, can the fan, so throttled, build up pressure to overcome this extra resistance?

In rising to the peak of the radial pressure curve in this case, the volume drops to about 60,000 c.f.m. and the pressure rises to about 15 in. How much would the system that is designed for 148,000 c.f.m. at 12 in. have to change to utilize the fan rising static to throw the fan performance to the peak of this curve? Note in Fig. 5, that sky-hooks will be needed to hold up the system curve, which has risen to the unbelievable amount of 90 in. static for 148,000 c.f.m. It is very interesting to note that under the same conditions, the drooping Sirocco curve is at the bottom, or in the "valley" of the "hump", while the radial fan is at its pressure peak, yet the Sirocco fan moves 54,000 c.f.m. while the rising static fan handles 61,000 c.f.m. The system resistance has increased 7½ times. The radial fan can't get over to its static peak to obtain this advantage. If such a condition did obtain, and the full 148,000 c.f.m. is required, the fan would have to be speeded up nearly 2½ times and would require nearly 10 times the original horsepower. Such system changes never occur except when a damper is used to control the volume with the fan operating at constant speed.

Fan Drive

The main question is whether the fan shall be operated at a single constant speed, at two or more speeds, or at variable speed. Turbine and engine drive do not bring up this question because they both operate at variable speed. The electric motor, however, is ideal when it is of the single, constant-speed type because of high efficiency and low installation and maintenance cost. The fan, however, wastes power when its output is controlled by means of dampers, when driven constantly at full speed, regardless of load conditions. As stated previously, an induced-draft fan moving abrasive gases scrubs out faster when operated full speed at all times, but controlled by dampers, whether the damper is in the outlet or the inlet of the fan. Electric motor drive, then, has originated this question of constant or variable speed. Radial dampers of various kinds have been provided in the inlets of fans to cut down some of the power losses of constant-speed damper operation. The power wasted by dampers is greater for the radial fan that is selected for "rising static reserve," because the damper is forced to restrict a greater pressure than if the fan is selected nearer the peak of the pressure curve.

It would be reasonable to assume that were it not for

the objection to variable speed a.c. motors, and for the expense and objection to d.c. auxiliaries, all fans would be driven at variable speed. From the standpoint of the fan this is desirable, especially induced-draft fans at high statics, say 7 in. or higher, where erosion is a problem and where considerable power goes into the fans. It is nothing unusual to see one plant use 14,000 to 18,000 hp. to drive its induced draft-fans alone; hence any saving of part of this power is of considerable importance.

One thing peculiar to the high-speed fan is that while it is purely non-overloading, dampering the fan at constant speed is more wasteful of power than dampering the other two types. The maximum power of the high-speed type is near the mechanical efficiency peak, and its "no-delivery" power is higher than the other two types; consequently it takes more power at dampered positions though it is very economical at its rated capacity. Hence the high speed fan should be operated at variable speed.

A very practical way to combine the highly desirable features of the constant-speed induction motor, or the synchronous motor, where power factor correction is desirable, is to use the hydraulic coupling which, despite the low ebb of present business, is finding its way into important power plants.

Hydraulic Coupling

With this device, illustrated in Fig. 6, the fan at full speed operates from 1 to 3 per cent slower than the driving motor. As fluid is removed from the coupling, the speed decreases proportionately until the fan operates at about 20 per cent of the motor speed, when all the fluid is removed, and windage inside the coupling drives the fan. At this low speed, the fan requires 0.8 per cent of its original horsepower.

There are 10 fundamental parts to this coupling:

1. The motor driven disc pump
2. A following disc turbine, or runner
3. Rotating enclosing casings
4. A liquid to transfer the power
5. A scoop tube to empty the coupling
6. An upper tank to store the liquid removed
7. A lower tank or sump
8. Means of automatically raising liquid from lower to upper tank after a shut-down
9. A weir to meter amount of fluid in the coupling
10. Means of operating and controlling weir position

Fig. 6 is a diagram to show the flow of oil and operation of the coupling. It does not show its exact construction.

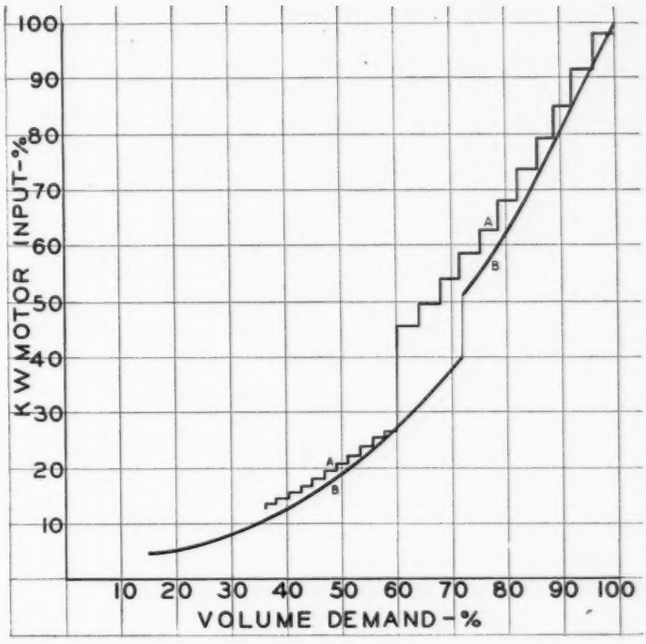


Fig. 9

Fan driven by two speed motor and hydraulic coupling compared with two slip ring motors without damper auxiliary control between steps and without damper control beyond low slip ring speed, viz: A—Two slip ring motor fan drive. B—Two speed motor and hydraulic coupling.

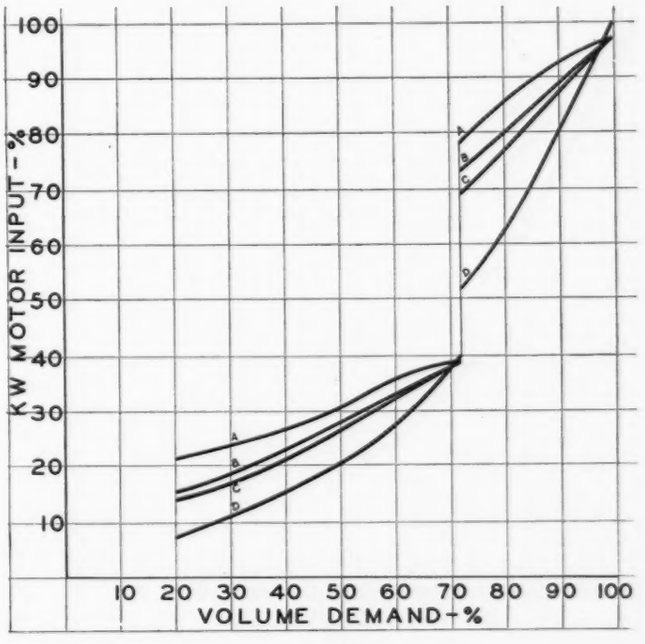


Fig. 10

Fan driven by two speed motor and hydraulic coupling compared with three types of fans driven by two speed motors and damper control, viz: A—High speed fan with backwardly inclined blades. B—Radial blade fan. C—Forward-curved blade fan. D—Any fan with hydraulic coupling drive.

Oil in the upper tank (W) is kept at any desired level by the movable weir (A). Oil in excess of that required to maintain the level flows over the weir (A) downward through the return pipe as indicated by arrows into the scoop tube housing (B). Cavities through this stuffing box conduct the oil to the center of the coupling where it is released between the impeller (D) and runner (C). The oil flows outward due to centrifugal action and enters the vortex between the runner and impeller, where it is put to work in transmitting power from the impeller to the runner. Oil collecting between the inner casing (FA) and the runner (C) is leaked off through small holes (E) into the cavity formed between the inner casing (FA) and outer casing (F). This oil, due to the rotative speed of the casing, forms an annular ring at the outer edge of this cavity. A

stationary scoop tube (G) attached to the scoop tube housing projects to near the outer surface of the interior cavity and with its open end pointed in a direction opposite from the rotation of the casing. Impact of the rotating oil with the scoop tube forces the oil into the scoop tube and upwards into the scoop tube housing and through the pipe (H) and (Y) back into the upper tank. When the coupling is shut down some of the remaining oil in the coupling will find its way out through the labyrinth joint (T) and through the cored space (P) in the manifold lower half into the lower tank (N). For the purpose of putting this oil back in service when the coupling is started again, a small amount of oil is taken off the return pipe (H) through pipe (J) and ejector (K). The ejector is connected to the lower tank (N) through a pipe (L) leading to the bottom of the tank. The discharge from the ejector passes through an individually cored hole (M) in the scoop tube housing back into the cavity between the inner and outer casing, where it is again picked up by the scoop tube. The ejector is in operation at all times while the coupling is running and assures a dry lower tank and keeps the entire charge of oil in active use. Only a small amount of oil is necessary for the operation of this ejector.

Fan Control

High efficiency of a boiler plant over a wide range of capacity is demanding fully automatic boiler control, though some operators still prefer semi-automatic for large stations. Fuel, air and feedwater ratios have to be kept in balance, and of course this means the output of the mechanical draft fans has to be changing constantly to coincide with the varying station load. So far as the boiler is concerned, it makes little difference how this is accomplished as long as it is flexible. For other considerations given, such as power economy, erosion reduction, noise reduction, etc., it was stated the preferred method is to vary the speed of the fan.

The hydraulic coupling is of particular interest to the engineer desiring an automatic control system. Attaching control instruments to the coupling to move its weir is a very simple matter.

Figs. 7 to 10 show how the three types of fans behave under these various conditions of constant and variable speed operation. These curves are general as they include the losses in the motor, coupling, and fan, whereas Figs. 4 and 5 are specifically taken from curves of definite fans. Hence, Figs. 7 to 10 will vary somewhat as they are applied to a given installation. However, they picture with fair accuracy the general relations they show.

In concluding the author wishes to refer briefly to the different types of fans as designated in this article. Practically all manufacturers of fans designate the backwardly-inclined blade fan as the high-speed fan. The radial blade fan is somewhat standard, except as each manufacturer chooses to modify its performance by blade variation. The forward-curved blade fan is also made by most manufacturers, with varying degrees of success. While this fan requires the greatest skill to develop its best possibilities, the author believes it offers the greatest reward for careful research and design.

Deslagging Device Acquired by Diamond Power Specialty Corporation

The Diamond Power Specialty Corporation has acquired patent and manufacturing rights to the deslagging device developed by H. T. Weis. This apparatus will be marketed as the Diamond Deslagger.

For the past several years the Diamond Corporation has been making a study of the deslagging problem and has developed the Diamond steam water mix apparatus to be used in connection with the Diamond Automatic Valved Soot Blower head in certain locations. The acquisition of the Weis device for operation in the hottest locations in the boiler completes a line of deslagging equipment which will cope with the problem in any boiler and under the conditions imposed by the various fuels used. The basis of the Diamond system of deslagging is the use of water, introduced into the boiler under high pressure through a nozzled element. The quantity of water is carefully gaged so that there is no detrimental effect on the boiler tubes or boiler settings.

The Diamond Deslagger is installed underneath and at right angles to the bottom row of boiler tubes, a short distance in front of the rear tube headers. It is hung from the boiler tubes by water-cooled hangers and the unit itself is likewise water-cooled. The cooling water flows in series, first through the annular space in the deslagger and then through the hanger. The high pressure water is supplied through a swivel joint, so that the deslagger element can be rotated through an arc of about 45 degrees.

Thomas A. Marsh has recently become a partner in the Ernest E. Lee Co., Chicago, manufacturers' representatives. Mr. Marsh was for ten years Chief Engineer of the Green Engineering Company, for seven years Western Engineer of the Combustion Engineering Corporation, and for three years President of the Modern Coal Burner Company.

The Ernest E. Lee Co. has just added the following accounts to its list: M. W. Kellogg, plastic refractories, Wyodak Chemical account, *Wyolite* insulation.

The Northern Equipment Co., Erie, Pa., manufacturers of Copes Feed Water Regulators, Differential Valves, Pump Governors and allied equipment, announce the following extensions of sales territories:

I. C. DeHaven Engineering Co., 1125-27 Circle Tower, Indianapolis, Copes representatives for the last 10 years, has been assigned all of northern Indiana with the exception of Porter, Lake, LaPorte, St. Joseph and Elkhart Counties.

Economy Equipment Co., Roosevelt Building, St. Louis, Copes representatives for the last two years, has been assigned all the state of Illinois south of the 40th parallel of latitude.

The J. W. Murphy Co., 431 South Dearborn Street, has been appointed Chicago district representatives for Copes Feed Water Regulators, Differential Valves, Pump Governors and allied equipment.

Patents*

By GEORGE RAMSEY
NEW YORK
Patent Lawyer
Member A. S. M. E.

This article deals with the transfer of title and patent rights, and points out the value of patents under various conditions. Mr. Ramsey discusses the character and kinds of licenses and calls attention to dangers to be avoided in the granting of licenses. The relations of employer and employee are discussed, and a "shop right" is explained. Grants and assignments are analyzed. The necessity for recording assignments and not recording licenses is discussed, and the rights of an inventor with respect to licensing or assigning an invention before the patent is granted are explained.

PART IX

Transfer of Title and Patent Rights

It may be one of several motives which induces an inventor to apply for a patent. Usually, the patent is obtained with the hope of securing some particular benefit from its operation. Where a patent is obtained on subject-matter relating to the commercial activities of the patentee, the benefits are immediately apparent. If the owner of the patent is an individual, a partnership, a company, or a corporation, engaged in manufacture, or sale of goods relating to the subject-matter of the patent, the patent may have been obtained to protect some improvement which it is intended to manufacture and sell, or the patent may have been secured to protect the manufacturer in the exclusive use of some improved machine especially useful in making his product. The patent may have been obtained or purchased to merely prevent some competitor from manufacturing a competing device which would interfere with the established business of the owner of the patent.

In the latter case, the patent may be said to be "laid on the shelf," but it is of substantial value to the owner because it operates to shut off or prevent competition as to its particular field. It operates in another sense, namely, to permit the owner, at some later date, to further expand and develop the patented invention under its claims. Such a patent may be likened to a door which opens in one direction. It is closed against any outside competition which comes against its barriers, but it opens from the inside to permit expansion of the business under its protecting scope. It has often been said that corporations buy up broad patents for the purpose of suppressing important advances in the art. If this happens at all, it is extremely rare, because all organizations and institutions which thrive must move forward. Therefore, new advances in the art are welcomed and developed rather than buried. Furthermore, the life of a patent is seventeen years. It is a public document which is open to all. Consequently, if it opens a new field and this field is not occupied during the time the patent protection exists, any company or corporation which bought up such patents would find itself in serious difficulty at the end of the patent period because someone else will step into the field and will quickly outstrip the slothful organization which had attempted to stem the tide of progress.

It is, of course, a common practice for corporations and manufacturers to take out patents on many detail improvements, which details are never actually used in their specific form. They may, however, be practiced in some other form which comes under the scope of the patent protection. The patent system, therefore, is one which automatically advances the progress of the useful arts. The effect of the system may be likened to a mechanical ratchet which catches and holds each step in the advancement of the art and transmits the force and effect of this advance to posterity.

There is another angle to the value of a patent owned by a corporation, company, or going concern, in that it becomes a part of the capital assets of the concern. This asset is of more or less indefinite value which may change as the relation of the business changes during commercial development. A patent which has been taken out as a general protective measure may suddenly become the foundation for a substantial portion of the business where some unforeseen term of events has changed the direction of exploitation into the field covered by the patent. Some years ago, a corporation sent to its attorney an article which a competitor had made and asked for a report on the patent situation as to this particular article. The officials of the corporation were astonished when the attorney advised that their corporation four years previously had patented the identical thing which the competitor had started to make. The result was that the competitor was notified of the patent and quit manufacturing the article. The crowd which had been asleep as to their opportunities immediately began to make this particular article under their own patent and it became a substantial part of their business.

* All Rights Reserved by the Author.

A further angle is that in case of sale or re-organization of a company or corporation, the principal assets are good will, real estate, second hand machines, and patents. The value of these assets may be fairly accurately estimated except as to patents, and as pointed out a patent of little value today may be of great value tomorrow. Therefore, this asset comprising patents may properly be given a value commensurate with what the purchaser or reorganizer is willing to pay.

It frequently happens that individuals will make inventions or discoveries entirely outside of their special line of vocation. In such cases, the individual usually is speculating. He hopes to obtain some benefit which exceeds the trouble and the cost to obtain a patent. In other words, he hopes to dispose of his patent rights in some way to obtain a profit therefrom. He may transmit these rights to others by three different ways.

First, he may issue a "license" under his patent. A license does not transfer title; it merely grants a privilege. *Second,* he may issue a "grant" under his patent, which is a transfer of title in the patent for some territory of the United States and possessions less than the whole United States and territories. *Third,* he may "assign" his patent. This is a transfer of a portion or the whole of his title for the whole of the United States and territories.

We will now proceed to analyze the effect of these different modes of disposing of patent rights.

Licenses

A true license is a contract. It does not transfer any part of the title of the patent. It is merely the extension of a privilege from the licensor to the licensee to the effect that the licensee may proceed to exploit the patented invention as specified in the license agreement without suit for infringement on the part of the owner of the patent because of this exploitation. In other words, it is a contract whereby the patent owner agrees not to enforce his rights against the licensee.

The contract may be limited to a specific form of the invention. If the licensee makes some form of the invention other than that specified in the license, he has gone beyond the privilege which has been extended to him and he is liable for infringement of the patent so far as he has exceeded the terms of the license. The license may be for a limited territory and it may be for a limited term. It may be subject to revocation or termination if certain specified conditions are not complied with by the licensee, dependent on the wording of the instrument. It is not unusual for a licensee to require a minimum royalty payment during the term of the license.

Since a patent secures to the patentee the right to exclude others from making, using, or selling the patented invention, he may grant licenses on any one of these rights, that is, he may license one party to manufacture; he may license another party to sell; and he may license a third party to use. Of course, the patentee may grant licenses on any two or all three of these rights to one party or to several parties as he sees fit.

There are two general types of licenses. First, a "non-exclusive" license; and second, an "exclusive" license. A non-exclusive license is one wherein privileges to use the patent rights may be extended to a number of different licensees wherein all the licensees have substantially the same privileges. An exclusive license is one wherein the privileges are given exclusively to one licensee and the licensor agrees not to give out any other licenses. The exclusive license may be substantially unlimited as will be pointed out later. A license may be exclusive in a particular field and non-exclusive as to the main invention. For example, a patentee of a fastening device may grant one licensee the exclusive right to make the fastener for use on hand baggage, and may grant another licensee the exclusive right to make the fastener for use on wearing apparel. In one sense, each licensee has an exclusive license, while in the general sense, these licenses are non-exclusive because more than one manufacturer is making the fasteners.

An exclusive license should be a carefully drawn instrument because an exclusive license which grants the exclusive right to make, sell, and use the patented invention throughout the complete territory covered by the patent, for the life of the patent, may be construed by the courts to be an assignment, because the licensor has passed on to the licensee all the rights the licensor had under the patent. Where this occurs, there is nothing left to the licensor and he has in legal effect transferred his title to the licensee. It has been held that where an attempt has been made to grant such a license, with certain privileges retained by the licensor, that the instrument was in effect an assignment from the licensor to the licensee so that the licensee became an assignee, who in turn in effect granted a license back to the original patentee as to the reserved privileges.

These difficulties may be avoided by granting an exclusive license for less than the full term of the patent. They may also be avoided by granting an executive license for less than the entire territory of the United States and possessions such as for example, specifically stating in the instrument that a certain small territory is not included within the license. They may also be avoided by granting a manufacturer the right to make and sell, but omitting from the license the right to use. This omission is not serious because the right to use so far as the public is concerned, automatically follows from the right to sell; that is, if a patentee grants a license to sell, he automatically extends to the purchaser the right to use the device purchased. However, where the right to use is omitted from the license, it leaves the legal fiction of the right to use exclusively in the patentee and thereby avoids the danger of the license being held an assignment.

Since licenses are the extension of a permission or privilege, licenses ordinarily are said to be personal in effect and extend only to the particular party which is licensed. Such licenses may not be transferred from one party to another, even with a transfer of the business. The licensee cannot, under these conditions, grant sub-licenses. He may, unless explicitly prohibited by the license contract, employ someone else to carry out the license for his benefit. It is entirely possible to make a license transferable by specifically so stating in the license contract. Where a license is a personal license granted to an individual, the license terminates on the death of either party, in the absence of some specific agreement whereby the license may be con-

tinued. Where a licensee becomes a bankrupt, the license may be terminated by the receiver the same as the receiver may terminate other contracts.

A licensor retains full control of the patent except for the privileges which he extends to the licensee, and, therefore, in a certain sense, the licensee acts as the agent for the licensor. Under this doctrine, the licensor may provide in the license agreement for fixing the price at which the licensee shall sell the licensed article. This has been held to be legal and not in conflict with the anti-trust laws. Where articles have once been sold and pass into commerce generally, both the licensee and the patentee have lost complete control of the device and no resale price restriction can be legally established. A perfectly legal right may become illegal where the legal right is used merely as a smoke screen to cover an illegal action. Therefore, where a license based on a patent is used to fix or maintain prices, the patent must be of some substantial substance and scope and not merely of such narrow scope as to cover only flimsy detail so as to be obviously an excuse for an illegal price fixing combination.

Since licenses are contracts, they are governed by the law of contracts which has become somewhat modified to fit the particular type of conditions arising in connection with patent property. A license under a patent need not be in writing; it may be oral. Oral licenses, like other oral contracts, depend upon proof, which may be difficult to produce, hence it is obviously far more desirable that the conditions of the contract shall be in writing. The real contract is the agreement between the parties and the writing is merely a memorandum of that agreement.

The interpretation of the license contract will depend first, on the wording of the contract, and second on the action of the parties in working under the contract. For example, if a license agreement is limited to cover a specific form of the invention, but the licensee proceeds to make a different form and the licensor accepts royalties on the different form and continues to do so with knowledge of what the licensee is doing, the parties have automatically extended the license to cover the form that was not originally contemplated in the written document.

It is not unusual in license contracts to provide that the owner of the patent shall protect the licensee against unauthorized use of the patent by others. This is particularly true where the license is an exclusive license. Therefore, under such conditions specified in the license, it is up to the owner of the patent to prosecute unauthorized uses of the patent, or in other words, to prosecute infringers, in order to protect his licensee. It will be observed, therefore, that the licensee is obtaining a benefit from his license, and because of taking the license and obtaining the benefit thereunder, he automatically recognizes the value of the patent. As a consequence, a licensee may not attack the validity of the patent in defense of a suit brought to collect royalties. He may, however, in certain cases, repudiate his license, stop paying license fees and then he is in the position of an infringer and has open to him all defenses against the patent as to his activities after he repudiated the license. He is in the position, however, of once having recognized the validity of the patent, and, by his own actions at least at one time in the existence of the patent, in effect, has said this patent is valid. The fact that he was once a licensee, consequently, increases his difficulties in convincing a Court that the patent is invalid. In the case a disagreement arises between a licensee and a patentee as to whether or not certain articles being made by the licensee are within the license, the licensee may contend that the articles which he is making do not come under the patent because they are articles which were old in the art before the invention of the patentee, and, therefore, the claims of the patent cannot be properly construed to cover such old articles. This is not an attack on the validity of the patent but is an assertion that the scope of the patent shall be properly limited to include only that which the patentee is legally entitled to cover. This, the licensee has a right to do, while at the same time retaining his license. Suits involving validity and infringement of patents must be brought in the Federal Courts. However, since licenses are contracts, suits for enforcement of a license or to recover license fees can only be brought in State Courts unless jurisdiction is conferred upon the Federal Courts by some fact or circumstances other than the mere fact that the suit happens to be brought on a license under a patent.

A license under a patent is not completely analogous to a license or lease upon real estate or similar property, the reason being that the license or lease of real estate or similar property is the grant of a positive right to use the property, whereas the license under the patent is not the grant of a positive right but is the grant of a negative right, in that it is merely an agreement that the licensee will not be sued by the patentee. The patentee himself, may not be entitled to practice his own invention as we have previously pointed out, and, therefore, the patentee can extend to the licensee only such rights as the patentee himself possesses. The patentee, however, may agree to hold the licensee harmless from infringement suits brought by third parties. This is purely a contractual obligation and is not necessarily based upon the patentee's patent. It is not unusual for such protection clauses to be included in a license agreement. On the other hand, the licensee may be satisfied to take his chances as to suits by third parties and may not ask for a protection clause from the patentee.

Licenses may grow out of the relationship of the parties. Such licenses are usually designated as "implied licenses". One situation which raises very troublesome legal questions is where the inventor is in the employ of a corporation or a manufacturer and makes an invention along the line of his employment.

Employer and Employee

In the absence of specific contract, the rights of an inventor to his invention are individual rights. Therefore, if an employee makes an invention, even though it be in the direct line of his employment, such invention does not ordinarily belong to the employer. However, where the employee makes an invention and the employer decides to exploit the invention, if the employee permits the employer to proceed to develop the invention and exploit the same commercially, without protest, the employer gets what is known as a "shop right" even though the employee may obtain a patent.

A "shop right" is a limited implied personal license. and, therefore, cannot be transferred even with the transfer of the business from one company to another. A shop right arises because the employee has not protested. If the employee promptly protests against the use of his invention by his employer, then no shop right arises. However, he may not be silent and let the employer exploit the invention, and then later decide to kick about it. It is the old case of "He who is silent when he should speak, will not be heard when he would speak." When a shop right has once been established, it will continue during the life of the patent. A shop right means the right to use the invention in the particular shop of the employer where the invention was first exploited. If the employer has a series of branch factories, it has been held that the employer may not use the shop right in some branch other than that where the shop right was originally exploited. A shop right, therefore, is so limited as to afford the employer very limited rights.

It has been held that an engineer who was employed to design railway cars but who was under no contract with the employer, had the right to obtain patents upon his inventions in railway cars and to leave the employment of his employer and go to a competitor to whom he could grant licenses or assign his patents. Under these conditions, the original employer brought suit to attempt to obtain the patents and to restrain the competitor from manufacturing the patented inventions. It was held that the first employer had a shop right only, and that he could not obtain title to the patents nor could he stop the second manufacturer from making the patented cars under a license or assignment from the inventor. It was also held that the President of a company manufacturing stoves and furnaces who made inventions along that line and who permitted his company to use these inventions could not be stopped from leaving the company and going into the manufacture of furnaces and stoves on exactly the same inventions which he had permitted his former company to use.

In order that the employer may properly protect himself, it is advisable that he shall enter into proper contracts with all his employees in order that he may obtain the benefits of his employees' inventions which advance the particular industry that affords them employment. It is usual that such contracts are entered into at the time of employment and that they shall cover a sufficiently broad scope to include inventions relating broadly to the industry being carried on and to such features as are probable fields of expansion of this particular industry. Such a contract may provide for some definite compensation for patentable inventions to be assigned to the employer, or it may be based upon the mere consideration of employment. In order to prevent an employee from making a valuable invention and then leaving his employer to obtain his patent, it is not unusual for such contracts to specify that any invention made within the field specified during the time of the employment, or within a specified number of years following the termination of employment, shall belong to the employer. Such contracts have been enforced by the Courts. The Courts have also enforced contracts limited to a specific field of invention for an indefinite period after the inventor has left the employment of the company concerned. Such contracts if covering the entire field of invention might be held void on the ground of public policy, in that they would stifle invention, interfere with a man earning his living, and prohibit an ingenious individual from conferring upon the public the benefit of his inventions. However, where the contract covers the period of the life of the inventor, but is limited to a definite specific line of inventions, for example, improvements in wire glass, it has been held that such a contract is enforceable; and where an inventor has entered into a contract to turn over to his employer any invention that he may ever make in a definite limited field, such a contract has been enforced by law.

From the foregoing, it will appear that it is important for the employer and also for the employee to know the general effect of the law as to such contracts and to enter into only such agreements as are fair under the circumstances. Where an inventor has been employed for the purpose of inventing a specific, definite, improvement, that is, where employment was based upon a specific job the results of which were to be exclusively for the benefit of his employer, it has been held that the invention belongs to the employer, and that instead of getting a mere shop right, the employer has full title to the entire invention and any patents that may issue thereon. Under these conditions, if the inventor desires to retain some rights under his invention, these facts should be clearly and unmistakably set forth in the contract between the parties. It is not unusual for an employer to contract for the rights of the invention as to the United States patents, but to permit the inventor to take out foreign patents for his own benefit. Under these conditions, the employer obtains substantial protection from the United States providing the patent covers a machine or an article of commerce, but if the invention relates to a process, then the foreign importation of articles produced by such a process may be sold and used in the United States in competition with such articles as are produced by use of the process by the manufacturer in the United States.

The purchase of a device or a machine carries with it the implied license to use the said machine for its normal uses. In the general sale of the machine, the materials normally used with it cannot be restricted, on the supposition that the general sale of the machine may be only a limited license. Some years ago, the Supreme Court decided that the maker of a mimeograph could enforce the conditions specified on a label on the machine to the effect that all ink used on the machine must be purchased from the manufacturer of the machine. A user of the machine bought ink elsewhere and was sued for infringing the patents on the machine. The Supreme Court sustained the decision finding infringement. The Supreme Court subsequently reversed this decision and it is now settled that the sale of a machine carries with it the right to buy supplies in the open market. Where a device is complete within itself but capable of being one unit or element in a combination, it does not follow that the purchaser of the device has a right to use it in a particular patented combination. Generally speaking, however, where a device is only useful in a particular combination, it may be used there-

in providing the patent on the combination is owned by the owner of the patent on the device. The reason for this is that the seller of the element or device must know that the device has but one use, and, therefore, he cannot legitimately sell the device to a purchaser and at the same time hold back the right to use. The same doctrine applies where a licensor owns a broad patent and a specific patent. If he grants a license under a specific patent, this grant will ordinarily automatically carry rights under the broad patent, the doctrine being that the licensor has no right to give a license with one hand for a valuable consideration and then attempt to take it away with the other hand, merely because he has a broad patent that covers the specific thing on which he granted the license.

While United States patents cover only the United States, it is entirely possible to grant a license under a United States patent and require the licensee to pay a license fee on every article he manufactures any place in the world. This condition is merely a condition of the contract and is not based upon foreign patents. The purchaser of the license is so anxious to get the license that he is willing to pay a licensee fee on every article he makes regardless of where it is made. Such a situation is not unusual.

Grants

A grant or an assignment is legally a very different instrument from a license. A grant or an assignment is a transfer of a part, or the whole of the title in the patent. A license as we have pointed out does not transfer title, but merely conveys a privilege. A license is purely a contract whereas an assignment is a deed. A "grant" is a limited territorial assignment. For example, a patentee may grant the sole and exclusive right to manufacture, sell, and use the patented invention for the life of the patent for the territory covered by specified geographical divisions of the United States, such as the State of New York, New Jersey and Pennsylvania. Within the territory specified, the grantee stands exactly the same as the patentee, and has complete control so far as the patent is concerned within this territory. He has no control whatever outside of his specified territory. Within this territory, he may make sub-grants or licenses of any proper kind. He may bring suit against infringers within the specified territory and can otherwise act within this territory as though he owned the entire patent. Grants may be for an undivided portion of the title or it may be for a whole title of a patent within the limited territory; that is, the patent owner may grant an undivided one-half of the title in his patent for the territory of New York, New Jersey, and Pennsylvania, or he may grant any other undivided part of the title that he sees fit. Grants are not unusual, but are less frequently used than licenses or assignments.

Assignments

An assignment of a patent comprises a deed to the part of the title specified in the assignment. The assignment may be for the whole title of the patent, or for an undivided portion thereof. There is no such thing as a dividing the title in a patent, any more than there is a possibility of dividing a live horse into parts without killing the horse. In other words, a patent is an entity which cannot be physically cut up. It is entirely possible to own a one-half interest in the horse, but that one-half interest is undivided and cannot be utilized without the rest of the horse. The same thing applies to a patent. Undivided interests are common types of assignments, but like the undivided horse to use him at all you must use the whole horse, so with patents the full use of the entire patent goes with the undivided interest. For example, if an assignor assigns a one-quarter of the title in his patent, the assignee of the one-fourth interest may do anything under the patent that he likes, but he cannot prevent the owner of the three-quarters of the title from having the same rights. The owner of a one-quarter interest in the patent may be an astute business man and may make a million dollars from his interest in the patent. The owner of the three-quarter interest, in the absence of special contact, cannot get one penny of the money that has been made by the owner of the small portion. The owner of the one-quarter may grant licenses without consulting in any way the owner of the three-fourths; he may sell his entire one-quarter or any portion thereof, and in general, he can act entirely independent from the owner of the three-quarters providing there is no contractual relation between the parties which limits the rights of the parties. Therefore, in making an assignment of an undivided part of the title in a patent, it is usually desirable to have a separate contract between the parties whereby mutual interests of the parties is equitably and fairly protected.

It is advisable that assignments shall be acknowledged before a notary public because the law provides that such an acknowledgment before a notary public shall be prima facie evidence of the execution of the assignment, grant, or conveyance. If the assignment is not executed before a notary public, but is merely witnessed by witnesses, it becomes necessary to prove the execution of the assignment should the execution in any way be questioned. The burden of proof in this case is upon the assignee who claims title under the assignment. Where the assignment has been executed before a notary public, the burden of proof is upon the party questioning the authenticity of the assignment.

The particular form for an assignment is not prescribed by law so, therefore, any clearly worded document which transfers all of the rights in the patent or an undivided portion thereof will be held to be an assignment. In interpreting a document, the Courts are not interested in the name by which the document is designated. It may be called a license, but the legal effect may be an assignment, and conversely, it may be called an assignment, whereas legally it may be merely a license. It is the substance of the instrument which controls and not its designation.

An assignment of an imperfect invention with all improvements thereon which the inventor may make has been held to be an assignment of the perfected results. A patentee or assignor may not sell or transfer his title to another and then buy or obtain control of an older broader patent and through such older and broader patent, attempt to dispossess his assignee of the full benefit of what he has purchased. An assignee of a patent may not later go into the field of manufactur-

ing articles and then set up a defense that the patent which he assigned is invalid. The law assumes that he sold a valid patent and will not hear him contradict this presumption. He may properly argue as a defense that the articles which he is making are not covered by the claims of the patent which he sold. Here again this is not an attack on the validity of his patent which he assigned but is merely the asking for a proper construction of the scope of the claims of the patent.

Where an inventor has assigned all of his rights under his invention and the patent that may issue thereon, he may be excluded from inspection of his application in the Patent Office, and the assignee shall have complete control of the application. Under these circumstances, there may be some question as to whether an assignor, if sued for infringement of his own patent, may not attack the validity of claims put into the application by way of amendment and which claims are broader than those to which he took oath as being the inventor. If the assignor can show that he had knowledge of some prior statutory bar, which would have prevented him from asserting broad inventorship, it seems reasonable and proper that he should be permitted to interpose this fact as a defense against such broad claims as were later introduced into the case when he had no opportunity of supervising or inspecting the case while pending in the Patent Office.

Where the owner of a patent either as patentee or assignee becomes bankrupt, the patent becomes a part of the assets of the bankrupt's estate and the trustee in bankruptcy is vested by law to the title of the patent. Such a patent may be sold or conveyed by the trustee in bankruptcy the same as any other property of the bankrupt. This raises a note of caution for the patentee in making agreements which are dependent upon a contingent purchase price. Where an assignment is made to a concern with agreements that the consideration shall be paid in the future and the concern goes bankrupt, a situation may arise in which the assignor becomes merely a creditor of the bankrupt, while the bankrupt may have full title to the patent. Under this situation, the assignor is out of luck. It is safer, therefore, to grant an exclusive license rather than make an assignment unless full payment is made at the time of transfer. Where the licensee holds an exclusive license, he has substantially the same rights under the patent as he would have if he owned the patent itself, but the title of the patent remains in the licensor. Therefore, in case of bankruptcy, the exclusive licensee, the bankrupt, does not own the patent. The patent, therefore, is not a part of the bankrupt's estate.

Recording Assignments

The laws provide that every patent or an interest therein shall be assignable by an instrument in writing and further specify that an assignment, grant, or conveyance shall be void as against any subsequent purchaser or mortgages for valuable consideration, without notice, unless it is recorded in the Patent Office within three months thereof or prior to such subsequent purchase or mortgage.

This requirement of the law makes it imperative that any instrument touching the title of a patent should be promptly recorded in the Patent Office. Since licenses are not transfers of title, licenses need not be recorded and since the law specifically states "every patent or interest therein" the law applies specifically to patents and not to applications. It, therefore, follows that there is no requirement in the law that the assignment of an application shall be recorded. The records in the Patent Office of assignments are open to the public and are free to be examined by anyone who wishes to inspect the same. Therefore, where the assignment of an application is recorded, this assignment will give full data as to the inventor, the title of the application, the serial number and the filing date. This information may be of value to an unscrupulous opponent with whom the application is thrown into interference. It also, to the extent of the information given, obviates the rule as to secrecy of pending applications. It is not an unusual practice to withhold the filing of assignments of an application until the application is allowed, or until the final fee is paid. If the assignment is forwarded to Washington with the final fee and the attention of the Patent Office is directed to the fact that the fee is being paid and an assignment is being forwarded for recording, the Patent Office will record the assignment and the patent will issue to the assignee. In the meantime, the withholding of the recording of the assignment has not jeopardized the right of the assignee because the law as to recording does not become applicable until after the patent issues. Then, an unrecorded assignment is void against a subsequent purchaser or mortgagee who purchases without notice of the rights of the assignee.

Licenses need not be recorded to be valid and enforcible. Usually a license contract contains agreements between the parties that are more or less private and which the parties may not wish to make public. However where a license is of a general nature it may be well to have it recorded. While the recording of the license may not be legal notice (since the law does not require recording of licenses) it may be actual notice to third parties and in some cases this is desirable. This is especially so in the case of an exclusive license.

The Patent Office will record any instrument which refers specifically to an application or to a patent. The Patent Office declines, however, to record general contracts which do not specifically refer to some application or patent. The Patent Office, however, has accepted employment contracts for recording where the employee mentioned in the contract is actually on record in the Patent Office as an inventor by having executed an application.

Unpatented Inventions May Be Licensed or Assigned

An inventor frequently is in doubt as to his right to license or assign his invention before he secures a patent. This he has the full legal right to do. It is a common practice for an inventor to assign his invention and any patents that may issue thereon before the patent is granted. The inventor often executes such an assignment when he executes his application. Where such an assignment is made and is recorded in the Patent Office, the patent will issue to the assignee. Where the inventor assigns his invention without reservation as to patents thereon, it is doubtful if the inventor has any rights upon which he personally may apply for foreign patents. The reason for this being that

having made a complete assignment of his invention, he has transferred any and all rights and benefits that may flow therefrom and consequently, and therefore. he places the assignee in his stead so far as his rights under the invention are concerned. To obviate any question on this point, it is advisable that the inventor shall specify in the assignment of the invention, that the assignment is limited to the United States and to any and all patents issued by the United States on the said invention. Where the inventor intends to give up all rights under his invention, it is equally wise to specify in the assignment that the inventor assigns his invention and any and all patents that may be granted thereon any place in the world.

Where a license or assignment is made before a patent is granted, the invention should be accurately identified. If an application for patent has been filed, the application may be referred to as disclosing the invention. The issuance of a license before the invention is patented, leaves the licensee in a secure position when the patent does issue. If a manufacturer proceeds to exploit an invention before it is patented and without any license from the inventor, he may find himself in serious difficulty when the patent issues, for the reason that the patentee has a right to bring a suit to stop all infringement as soon as the patent is granted. Anyone has a right to make, sell, and use an unpatented invention but the day when the patent issues, these rights stop. This right extends to the users of the manufactured articles which were made before the patent issues, but which are used after the patent issues. Furthermore, the manufacturer is usually in position to obtain a more favorable license before the patent issues than after it issues. Consequently, the manufacturer who has taken a chance when he knows the inventor has an application pending, may find his business seriously jeopardized as soon as the patent issues.

While licenses may be oral; the law provides that assignments must be in writing. This is due to the inherent difference between licenses which are contracts and assignments which are deeds. In connection with licenses and assignments, it frequently happens that, in negotiations between a patentee and other parties, agreements will be entered into. It is not unusual that these agreements shall be a contract agreeing to the making of a license or agreeing to the making of an assignment. A clear distinction should be noted between an agreement to do something and the instrument which actually carries what had been agreed to. It frequently happens that an agreement to make a license or an assignment will be made and then nothing further will be done, the parties assuming that this agreement automatically closes the deal. This is not the case. Where an agreement to enter into a license or assignment is made, then the parties should complete the transaction by going ahead and making the actual license or the actual assignment. In the case where the transaction is never completed, the only rights which the parties have is the right to bring a suit to compel the other party to carry out the agreement. They have no rights under the patent itself until the agreement is carried out by the making of the license or assignment.

Electrical Industry Exhibit At Century of Progress

One of the most impressive exhibits at the Century of Progress exposition, to take place in Chicago this summer, will be that of the electrical industry. A principal feature of this exhibit will be a diorama, 90 feet in length, depicting the production and distribution of electricity. This immense plastic picture shows a high head water power plant tucked in at a mountain foot, a low head hydro plant utilizing the greater volume and lesser fall of water farther down on the plain, and a steam station located in a populous city. Transmission lines and substations link these power producers into an interconnected system from which are fed the homes, businesses and industries of the city and the prosperous farms on the countryside.

The diorama will be animated with lights and flowing water, spinning turbines and all the movement of busy life. A recorded voice issuing from a hidden source will point out the features of the diorama and trace the flow of electricity from generation to final use. A sequence of light and darkness on the scene will simulate day and night so that the observer will see windows begin to glow at dusk and shadowy streets become paths of brightness. By seeing as a whole the complete picture of electricity generation, distribution and use, its various components properly related and connected to each other, anyone who gazes on this diorama must take away with him a clearer conception of what constitutes an electric service system.

Other interesting features of this exhibit will be working models of basic devices, and machines designed to show physical processes in the production of electricity will answer questions by demonstration as fast as they spring into the mind of the visitor. Flows of vari-colored liquids in a simplified glass replica of a boiler will show how water is turned into steam to drive power plant turbines. A large size section of a turbo-generator with wheels and rotor in full relief will expose the interior mechanism of this most important machine.

Refractory & Engineering Corporation, New York, manufacturers of refractory cements and insulations, has purchased the former plant and equipment of the Merion Magnesia Corporation at Valley Forge, Pa. The new plant, as well as the present plants at Bayway and Netcong, N. J., will be used for the manufacture of the new insulations developed by the Refractory Company.

The Plibrico Jointless Firebrick Company, Chicago, Ill., announces the appointment of John S. Hayes as distributor for Plibrico Jointless Firebrick and other refractory products at Toledo, Ohio. Mr. Hayes will make his headquarters at the Baier Transfer & Storage Co., 347 S. Erie Street, where a warehouse stock of Plibrico materials will be maintained.

The Selection of Stokers

By JOHN VAN BRUNT Vice President in Charge of Engineering
Combustion Engineering Corporation, New York

The author classifies coals broadly with respect to those properties which influence the selection of stokers. He then discusses the principal types of stokers and shows their relative adaptability to different kinds of coal. Subsequent parts of the article are devoted to determining the proper size of stoker, combustion rates, furnace volume, preheated air, and the limitations of stokers as compared to pulverized coal equipment with respect to boiler capacities. The closing paragraphs give practical size ranges for the different types of stokers.

THE primary data from which the choice of a stoker must be made are (1)—the size of the boiler or boilers, (2)—the required output of steam, both continuous and short peak, and (3)—the kind of coal or coals.

The kind of coal determines the type of stoker. Any stoker will burn any kind of coal with fair, or very poor results, but *no* stoker will burn any kind of coal with equal efficiency or satisfaction. The size of the stoker is of course determined by the size of the boiler and the required normal and maximum output.

Probably as many errors in judgment are made in the selection of the type of stoker as in size. An unsuitable type can never give satisfactory service at any capacity.

The coals of the United States vary over a wide range of chemical composition, heating value, physical characteristics and burning characteristics.

Of these four characteristics the most important one is the way in which the coal acts when burning. That is, whether it cokes or cakes.

For our immediate purpose we will briefly note the most widely used coals.

In the Eastern part of Pennsylvania, we have anthracite with a volatile content of 3 to 7 per cent, ash 10 to 20 per cent, heating value 10,000 to 13,000 B.t.u. Each particle of this coal burns by itself without fusing to adjacent particles. Farther west in Pennsylvania we find Pennsylvania semi-bituminous, having 13 to 25 per cent volatile, 5 to 10 per cent ash and heating value 13,000 to 14,000 B.t.u.

In West Virginia both low and high volatile coals are mined, the former in the eastern part. New River and Pocahontas are representative of the low volatile coals—volatile 17 to 20 per cent, ash 5 to 7 per cent. These coals tend to cake, and coke also to some extent.

Pennsylvania and Ohio bituminous coals include a wide range of characteristics—volatile 30 to 35 per cent, ash 8 to 12 per cent. Most of these coals coke more or less strongly.

As we go farther west the coal becomes of lower grade, volatile and ash increases somewhat, also moisture and uncombined oxygen. Western Kentucky, Indiana, and Illinois coals are representative of a type that cake or coke but slightly, hence are termed free burning. Going farther west, Iowa and Missouri coals are usually somewhat poorer than Illinois—volatile 35 to 40 per cent and ash 15 to 20 per cent. These are also free burning. Sub-bituminous and lignite are recognized by their high moisture content, 22 and 35 per cent respectively, and are also free burning or non-coking.

In addition to the above sketchily outlined characteristics, the softening temperature or melting point of the ash is an important consideration which has considerable bearing on the limiting rate of combustion and on the maintenance of furnace refractories.

To burn these coals there are two general or major types of stokers—overfeed and underfeed. Each general type has variations.

The overfeed types include front feed and side feed or V furnaces, and also the traveling or chain grate. The underfeed, as the name implies, is a stoker in which the green coal is introduced and fed into the furnace beneath the fuel bed; there are two general types—the multiple retort and the single retort, both of which require forced draft. Of these various types only three are in extensive use today in industrial utility and heating plants—the multiple-retort and single-retort underfeed and the traveling or chain grate.

Traveling or chain grates are of two general types as to structure: the chain grate consisting of a large number of link castings held together by bars constituting a flexible chain, and the traveling grate composed of laterally arranged grate bars or supporting bars, carrying fuel supporting castings on top and in turn carried by two or more steel chains.

Either type may be used with natural or forced draft, although generally speaking the traveling grate is used with forced draft.

Having these four types available, multiple-retort and single-retort underfeed and forced-draft or natural draft chain or traveling grates, we must decide what type to use for the particular coal we are to burn.

Fundamentally the coal which cokes or cakes to any material extent must be agitated to some extent while coking and burning, while those coals that coke or cake but slightly should be burned without agitation.

From the very nature of the underfeed stoker, the incoming coal which is forced up beneath the burning fuel

provides the necessary agitation for coals of the coking type.

On the other hand, the chain grate on which the coal is deposited in a uniform layer at the front end of a horizontally moving grate, causing no agitation or relative movement of the particles of coal in the fuel bed, is the correct selection for the free-burning coals.

There are of course many border line cases, that is, coals which can be satisfactorily burned on both underfeed and chain grates; also many of the free-burning bituminous coals may be satisfactorily burned on underfeed stokers.

Anthracite and coke breeze cannot be handled with any degree of satisfaction on underfeed stokers, and, without exception, should be burned on forced-draft traveling grates or chain grates.

On the other hand strongly coking and caking coals should always be burned on underfeed stokers. For lignite and sub-bituminous and mid-west bituminous, the forced-draft chain grate will be the best selection.

There are however many cases of applications to existing boilers where the cost of a chain grate installation would be excessive. In such cases a satisfactory installation may be made with underfeed stokers of the single-retort type, particularly in connection with boilers of 500 hp. or less.

Summarizing the foregoing we find that we should use for anthracite and coke breeze—forced-draft traveling-grate stokers; for semi-bituminous and bituminous, coking or caking—underfeed stokers; for free-burning bituminous, sub-bituminous, and lignite—chain-grate stokers; for free-burning bituminous and sub-bituminous, under some conditions—underfeed stokers.

Coals very low in ash and of high heat value, should not, in general, be burned on chain grates as without a fairly thick bed of ash the grate is not sufficiently protected from the heat of the furnace and high repair costs will result.

Coals that are very high in ash will not coke to any great extent and may be burned to best advantage on a chain-grate stoker. For example, refuse from coal washeries having 20 per cent or more of ash makes an excellent fuel for chain grates even though the parent coal is a strongly coking coal entirely unsuitable for use on such grates.

Now as to the selection of size. Knowing the size of boiler and the normal and peak demand, the weight of coal may be readily figured from the weight of steam, its pressure and temperature, the temperature of feedwater and the expected combined efficiency of the boiler and stoker.

The equation may be expressed as follows:

$$\text{Lb. of coal per hr.} = \frac{W \times [H - (t - 32)]}{E \times \text{B.T.U.}}$$

in which

W = weight of steam per hour

H = Total heat in steam at boiler or superheater outlet

t = Temperature of feedwater

To select the size we must know how much of a given coal can be burned per square foot of grate surface on any type of stoker, and here again is where many errors of judgment are made.

We read occasionally of combustion rates of 50, 60 or 70 lb. per sq. ft. In locomotives rates up to 100 lb. per sq. ft. of grate and more are obtained. These high rates should not be permitted to cloud our judgment. A manufacturer of stokers should know the economic limit of combustion rates on his equipment. Unfortunately competitive conditions frequently cause him to stretch his conscience somewhat and sell a stoker smaller than the size required to do a satisfactory job. It will be found that on an official test under expert supervision the guaranteed results are obtained, but the installation is not always a pleasant one to live with in the following years.

High combustion rates mean high temperatures in the fuel bed and high temperatures, particularly on some types of stokers and with some coals, produce troublesome clinkers in the furnace. Ashpit losses also increase rapidly with increasing rates of combustion, as do the losses due to unburned carbon carried out of the furnace in suspension in the gases.

The stoker buyer should therefore question carefully any claims that continuous combustion rates in excess of 40 lb. per sq. ft. of grate will not be excessive.

On multiple-retort and single-retort stokers with a high grade semi-bituminous coal an average rate ranging between 30 and 45 lb., will be found satisfactory. For short peaks of one to two hours the rate may go as high as 50, 55 or even 60 lb., but it is not advisable to go above 55 lb. except at rare intervals and then only with exceptionally good coal, particularly if economy is desired.

With coal of higher ash content it is desirable to hold to the lower figures of 30 lb. to 35 lb. for continuous operation, and 40 to 50 lb. for peaks.

On the single-retort type the best efficiency will be found with a fair to good coal at 25 to 35 lb. with peaks up to 45 lb. High ash of low melting point will further lower these permissible rates.

Anthracite and coke breeze may be burned on traveling grate stokers at 25 to 30 lb. per sq. ft. at good efficiency and up to 40 to 45 lb. for short peaks; higher continuous rates than 30 lb. result in rapidly increasing loss due to fine particles of unburned coal carried through the boiler. When referring to anthracite for use on stokers, the writer means that size known to the trade as barley or No. 3 buckwheat, screened through a $\frac{3}{16}$-in. screen and over a 3/32-in. or $\frac{1}{16}$-in. No. 4 buckwheat, through a 3/32 and over a 3/64-in. screen, may also be burned effectively on traveling grates of special design at a rate of 25 to 40 lb.

Non-coking or free-burning bituminous coals may be burned on forced-draft chain grates at rates of 25 to 45 lb. per sq. ft. for continuous operation and up to 55 and in some cases 60 lb. for short peaks. Forty pounds is about the most economical rate although the combustion efficiency is higher at 30 lb. than at higher rates.

The natural-draft chain grate is not as generally used today as was the case 20 years ago. Its limitations as to capacity and efficiency will usually preclude its use except in plants where coal is cheap, the load fairly steady, and economy of minor consideration.

In selecting chain or traveling grates, it is important to note the one essential difference in design, and particularly the action of the grate, or the relative movement of the grate links of the former type as the chain passes over the rear drum or sprocket. This action

will break loose any clinker which may adhere to the grate. In the traveling grate there is no such relative movement between adjacent parts, and hence a badly clinkering ash will adhere to the grate and will prevent air from reaching the coal.

For bituminous coals therefore, the chain grate is to be preferred to the traveling grate.

While the per cent of ash and its fusion temperature very definitely limit the performance of underfeed stokers, it has no such limit on chain grate until the ash content passes 18 or 20 per cent. It is possible to burn coal having an ash content of 30 or even 40 per cent, and obtain quite satisfactory results.

The size of boiler, its output and the kind of coal being known, we can decide what type of stoker should be used and determine the area of the stoker.

So far our problem has been relatively simple. It is when we try to fit our stoker to the specified size of boiler that difficulties may arise.

The size or capacity of a boiler is determined by the number of square feet of heating surface in it. Each square foot will evaporate so much water depending on how much coal can be burned under it. A boiler of a given size may be wide or narrow. For example, we can get an 800 hp. boiler with a furnace 10 ft. wide, 15 ft. wide or 20 ft. wide.

If the boiler selected has an unusually narrow furnace it may be quite possible that we can find no stoker long enough to provide the required grate area, and on the other hand if the furnace is extremely wide it may be difficult to fit the furnace to the best advantage with a wide stoker.

The high or deep narrow boiler is usually lower in cost than the wider boiler of the same size but its selection may and frequently does require a higher priced stoker.

Much difficulty may be avoided if the buyer of such equipment consults the stoker manufacturer before determining the details of the size of boiler, that is, before fixing the furnace width.

If we find that the width of the furnace is such that we can install the required grate area, there remain the setting height or furnace volume and the details of the furnace brickwork.

Furnace volume is a most important factor in successful stoker operation, and as in practically all installations the stoker occupies the full width of the furnace, the required volume can only be obtained by setting the boiler at such a height that the product of the grate area and the vertical distance from the grate to the boiler tubes equals the required volume.

It is only recently or since the wide use of pulverized coal that stoker installations have been compared on a basis of heat release per cubic foot of furnace.

It is a mistake to compare the heat release of stokers with pulverized coal because the conditions are not comparable. In pulverized coal furnaces all of the coal is burned in suspension whereas in stoker installations 60 per cent of the weight of fuel is burned on the grate and 40 per cent in the space above the grate. If, therefore, the total B.t.u. released per hour by burning coal on a stoker is divided by the volume of the furnace we may find a rate of 50,000 B.t.u. per cu. ft. per hour. Actually the heat release in the space above the grate would be .40 × 50,000 or 20,000 B.t.u.

For coal of high ash fusion temperature, the total rate should not greatly exceed 60,000 B.t.u. per cu. ft. for continuous operation.

If the ash has a low melting point it is advisable to provide a volume or a height of furnace that will result in a total heat release of 40,000 to 50,000 B.t.u. per cu. ft.

As above noted the actual release in the space above the grate in these two cases would be 25,000 and 16,000 to 20,000 B.t.u. respectively, figures that compare fairly closely with permissible heat release in pulverized coal furnaces with the same coals.

These figures of heat release per unit of volume have no direct relation to combustion rates expressed in pounds of coal per square foot of grate.

It can be readily seen that a grate and furnace may be so proportioned that there might be an extremely high rate per square foot of grate and a low rate per unit of volume. Conversely a stoker of large area with insufficient furnace height would result in a low rate expressed in pounds of coal per square foot of grate and a high rate of release per cubic foot of volume.

A high rate of combustion per square foot of grate means a hot fuel bed and a high rate of release per cubic foot of furnace space results in a hot furnace.

If the height of the furnace is not sufficient it will not be possible to secure complete combustion within the furnace. Unburned gas will enter the boiler tube bank, combustible losses will be high and there will usually be smoke. Smoke, in itself, is only an indication of poor combustion conditions and losses. The actual loss is due to carbon monoxide and unburned hydrogen, or hydrocarbons.

Inadequate furnaces are usually troublesome because of the rapid accumulation of ash on the boiler tubes. If the ash has a low softening temperature the difficulties are aggravated. These slag accumulations are formed either by the impingement of fluid or semi-fluid particles of ash which stick to the tubes, or by particles of solid ash and carbon or coke which adhere to the tubes, once the surface of the tube becomes coated with a thin layer of dust or ash. Carbon particles that adhere burn slowly leaving a deposit of ash. If the ash has a low melting point, these masses of ash become fused and can only be removed by taking the boiler out of service and sending men inside to remove it. Soot blowers are not usually effective.

High combustion rates on any stokers, underfeed or chain grates, necessitate high velocity of air through the fuel bed. Small particles of coal are picked up in this high velocity air stream and are carried up through the furnace and are partly deposited in the boiler passes, soot hopper, breeching or base of stack. A considerable portion is discharged to the atmosphere.

This carbon constitutes a loss of considerable magnitude, particularly when the raw coal contains a large portion of fines.

For example, when burning anthracite screened through a ⅛-in. screen and over a 1/32-in., at a rate of 55 lb. per sq. ft., as much as 14 per cent of the weight of coal as fired will be lost in soot in the boiler passes and out of the stack.

Again Pocahontas coal which is usually mostly fines,

when burned at 65 to 70 lb. per sq. ft. on a multiple-retort stoker will entail a loss of 15 to 18 per cent. This is the principal reason for the rapidly decreasing efficiency, with greatly increased combustion rates. At 30 to 40 lb., the loss is not serious but the increase in such loss is approximately as the square of the combustion rates.

Thus, if at 30 lb. per sq. ft. combustion rate the loss due to unburned carbon in the gases of combustion is 2 per cent, at 60 lb. the loss would be about 8 per cent, and at 75 lb.—12½ per cent.

The comparatively recent development and extensive use of air preheaters has had its effect on stoker design and performance.

The gain in efficiency due to preheated air *may* be confined solely to the heat recovered in the preheated air as measured by its rise in temperature. The B.t.u. saved = W × specific heat (t_1-t_2) in which W = weight of air, t_1 = air temperature leaving air heater, t_2 = air temperature entering air heater. In some cases, notably with underfeed stokers and coking coals, the influence of preheated air on the fuel bed is marked. It has been found with some coals that a comparatively moderate degree of preheat results in a thinner and more uniform fuel bed with a decrease in excess air and a lower undergrate pressure.

Preheated air, however, will increase the temperature of the grate be it underfeed or chain grate and to some extent, depending of course on the temperature of the air, will increase the cost of maintenance of the stoker.

We know that cast iron grows or increases in size when its temperature passes about 450 fahr. Obviously if the combustion air is preheated to 500 fahr. all of the grate will be above that temperature and its rate of growth will be rapid; also the rate of oxidation or burning will be rapid. The temperature of preheated air, when used with stokers, should not exceed 300 fahr.

One of the reasons for the adoption of pulverized coal firing by many central stations was the fact that so much more coal could be burned in that form that it was possible and practicable to increase the size and capacity of boiler units considerably beyond that practicable with any type of stoker.

The exceptional results obtained with pulverized coal has greatly popularized its use and have also led to its application in many cases where stokers should have been used.

For extremely large units pulverized coal is the preferred and logical method of firing, but capacities up to 250,000 or 300,000 lb. may be obtained by chain grate stokers. In double end or W type boilers fitted with multiple-retort stokers at each end, capacities up to 450,000 lb. may be obtained. In one installation recently completed, a single multiple-retort stoker is guaranteed to produce 480,000 lb. of steam per hr.

Now as to the possible sizes of stokers—

The single retort underfeed stoker may be had in grate areas as small as 4 or 5 sq. ft., in fact stokers of this type are built to fit into small house boilers. For industrial or power boilers, single-retort stokers range from 25 sq. ft. of grate up to 120 sq. ft. This is about the upper limit for a single machine. For boiler furnaces wider than 12 ft., two stokers may be used.

In the multiple retort class, stokers may be had of any width up to the maximum width of furnace in use or projected. The length is usually limited to about 18 ft. from front wall to back wall. Thus in a 30 ft. wide furnace a stoker of 540 sq. ft. can be installed. Some few stokers have been made longer than 18 ft. but they have not all been entirely satisfactory due to the difficulty of controlling the fuel bed over the lower end.

Natural-draft chain grates have been built up to about 160 sq. ft.; most of these, however, range from 50 to 120 sq. ft.

Forced-draft chain grates are obtainable in sizes from 50 to 530 sq. ft. Very few of the smaller sizes have been installed. Forced-draft traveling grates are made in sizes from 36 up to 530 sq. ft.

It may be seen, therefore, that stokers are available in sizes capable of burning up to 25,000 lb. of coal per hr. in the case of chain grates and 35,000 lb. for multiple retort stokers.

The limitations given in this article are not intended as inflexible rules in the selection of stokers. They represent the conclusions drawn from 35 years of observation of many stoker installations of all types using all kinds of coal. Undoubtedly, there are many installations where the limits stated have been considerably exceeded. Such installations are, however, few in number as compared with those where disregard of these limitations have resulted in total failure or unsatisfactory performance, with consequent loss to both buyer and stoker manufacturer.

I. E. C. Publication on Steam Turbines Now Available

The Advisory Committee of the I. E. C., known as No. 5 on Steam Turbines, as a result of correspondence between the ten member-countries of the Committee and of meetings held in London and Stockholm in 1929 and 1930 respectively, has finally completed two documents covering the purchase and testing of steam turbines. These documents are now available in pamphlet form and may be obtained by writing to the American Society of Mechanical Engineers, 29 West 39th Street, New York. Ask for Part I, Specification, and Part II, Rules for Acceptance Tests, of the I. E. C. Publication on Steam Turbines.

Correction

In the article describing the new St. Nicholas central steam plant of the Philadelphia & Reading Coal & Iron Company, published in the March issue of *Combustion,* identification of the boiler baffling was omitted from the table of equipment data. This baffling, which was commented on in the article because of its unusual design and the low draft loss resulting from its use, was installed by The Engineer Company, New York.

Steam Releasing Surface, or Steam Releasing Space?

By Dr. ING. H. VORKAUF, Berlin

This is an abstracted translation of an article published in the November 1932 issue of our German contemporary "Archiv Fur Warmewirtschaft und Dampfkesselwesen." It gives details of some interesting experiments conducted to determine the effect of steam releasing surface and steam releasing space upon steaming capacity and the moisture content of steam. These experiments indicated that the volume of the steam releasing space rather than the area of the steam releasing surface determines the steaming capacity of a boiler drum and that the volume of the steam releasing space influences the moisture content of the steam. It was also shown that the volume of the steam releasing space as a factor determining steaming capacity was unaffected by the geometrical relationships of the space.

THE measure of permissible steam release from a boiler has heretofore been based on the steam releasing surface in steam drums. With recent boiler constructions, the conditions involved when considering the release of steam have changed so that it is questionable whether the capacity of the steam releasing surface is an actual measure of the steaming capacity of a boiler.

Experiments conducted by Eberle in the Technical High School, Darmstadt, involved the influences of steam releasing surface, steam space height, etc., upon the moisture content in the steam[1]. It was shown that in a steam space of a given height and steam releasing surface, up to a certain limit no water was entrained with the steam. This loading was designated by Eberle as the permissible loading; it changed, for a given steam releasing surface with the increase in the height of the steam space, from which one may conclude that the surface alone is not a correct measure for the conditions of steam release..

If you compare the steam release in two containers having high and low steam spaces respectively and the same steam releasing surface, you find that in the former considerably more steam may be generated than in the latter without carry-over of water. In the limiting case of an extremely small steam space height, the permissible steaming capacity becomes zero despite the same steam releasing surface.

When you speak of the steam releasing surface as a measure for obtaining dry steam, you unconsciously include a given steam space height. One may assume that, with the usual boilers, the steam space height maintains a given relation to the steam releasing surface. For example, in Fig. 1, the steam space height is half the drum diameter. As the water level rises within the drum, the relation of steam space height to drum diameter becomes smaller.

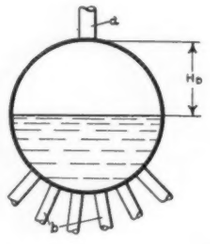


Fig. 1—Top drum having the water level at the middle of the drum.

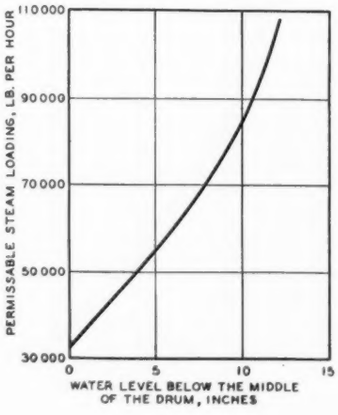


Fig. 2—Increase in permissible loading of the steam space of a drum of 40 in. I.D. and 12 ft. length in relation to drop in water level below the middle of the drum, at a steam pressure of over 270 lb.

Even if a given ratio of steam space height to drum diameter be assumed, the loading of the steam releasing surface is thereby not clearly determined. For, should you double the diameter of a drum, as shown in Fig. 1 having a constant length, the steam-releasing surface is likewise doubled. If you consider the steam releasing surface as a measure, then double the steam should be released. According to experiments in the Heat Technique Institute in Darmstadt made with pure water, the steam releasing space has been found to be the correct measure. When doubling the drum diameter, the steam release becomes fourfold.

Similar results of experiments appear when using caustic water. The steam releasing space is again the proper measure, although in this case the introduction of the steam and water mixture and the steam space height, or the static height of the foam and the stability of the foam have their various influences.

It has been common belief that when the water level

[1] Archiv-für Wärmewirtschaft. Vol. 10 (1929), p. 329.
[2] Archiv für Wärmewirtschaft. Vol. 12 (1931), p. 119.

sinks below the middle of the drum there will be danger of the boilers foaming over because the steam releasing surface decreases and is, as a consequence, overloaded. This view is contrary to the results of the cited experiments. The rise of the permissible loading of the steam

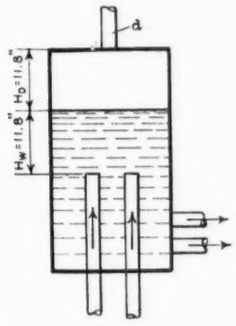


Fig. 3—Arrangement for investigating the permissible loading of an upright cylindrical steam space.

Permissible loading 200 lb. per hr. at 14.7 abs. or 5550 cu. ft. per hr. for 3 cu. ft. of steam space; permissible loading for 1 cu. ft. of steam space 1850 cu. ft. per hr.; steam releasing surface 3.03 sq. ft.; loading of steam releasing surface 1820 cu. ft. per sq. ft. per hr.; Ho steam space height; Hw water level above tubes.

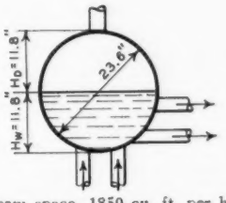


Fig. 4—Arrangement for investigating the permissible loading of the steam releasing space of a horizontal drum.

Permissible loading 185 lb. per hr. at 14.7 abs. or 5080 cu. ft. per hr. for 2.75 cu. ft. of steam space; permissible loading for 1 cu. ft. of steam space, 1850 cu. ft. per hr.; steam releasing surface, 3.55 sq. ft.; loading of steam releasing surface, 1430 cu. ft. per sq. ft. per hr.; Ho steam space height; Hw water level above tubes.

space of a drum when dropping the water level below the middle is shown in Fig. 2; the curve was calculated from test results made on caustic waters, during which tests the steam entered the drum in accordance with Fig. 1. It is clear that, with dropping water level, the drum may be loaded more, even though the steam releasing surface becomes smaller.

Selikin[2] investigated the influence of the steam releasing surface by covering over some of the surface and found that in spite of covering 70 per cent of the steam releasing surface, the permissible loading under the usual conditions was only reduced by about 10 per cent. The cause of this reduction may possibly be independent of the change in steam releasing surface, and may be attributed to the change in the entrance of the steam and water mixture into the steam space, because the covered portion robs the steam space of some of its effectiveness.

The geometrical relationships of a steam space do not influence the steam release within broad limits; according to experiments with two different steam spaces, see Figs. 3 and 4, which were fed with the same water and had the same height above the point of steam entrance, as well as the same steam space height. Their only difference then lies in the shape of the steam space over the unit area of water surface. The results were, with increase in steaming capacity, proportionate to the size of the steam space, that is, the specific increase in loading for a unit steam space was in both cases alike.

When determining the specific loading, one must, in every case, also consider the influence of steam pressures, the influence of the entrance of the steam water mixture and the steam space height. The allowable loading should therefore be based on the steam volume rather than on the steam releasing surface so as to avoid false representations with regard to the capacity of a boiler for delivering dry steam.

The Swartwout Company, Cleveland, Ohio, has appointed George H. Thomson, New England sales representative for the entire line of Swartwout power plant equipment and rotary ball bearing ventilator, with headquarters at 58 Brookline Street, Cambridge, Mass. Mr. Thomson has been associated with the Swartwout Company for more than 10 years.

W. P. Thomas has been elected president of the Diamond Power Specialty Corporation, Detroit, Mich., and of the Diamond Specialty Limited, Windsor, Ontario, Canada, to succeed Mr. Norman L. Snow, who died January 27th. Mr. Thomas has been associated with Diamond for seventeen years successively as chief engineer, secretary, and vice-president.

Obituary Notices

Charles MacCaughey Sames, associate editor of The American Society of Mechanical Engineers since 1916, died suddenly at his residence in New York City on March 8, 1933.

Mr. Sames was born in 1866 at Rockford, Ill. Matriculating at the Worcester Polytechnic Institute, Mr. Sames soon transferred to the newly-formed Rose Polytechnic Institute at Terre Haute, Ind., from which he was graduated with the degree of Bachelor of Science.

After his graduation, Mr. Sames came East and entered the employ of the Thomson-Houston Electric Company, Lynn, Mass. In a short time he returned to his native town and entered business with his father, who was a manufacturer of agricultural implements. He continued in this business, first as superintendent and then as business manager, until 1900 when he entered upon his editorial career.

Mr. Sames' first venture in literary and editorial work was the compilation and editing of a "Pocket Book of Mechanical Engineering." This "pocket book" contained valuable data gleaned from publications in foreign languages and for that reason not available to the average engineer. Later, he assisted Professor Lionel S. Marks in the preparation of Marks' "Mechanical Engineers' Handbook."

In 1916 Mr. Sames joined the staff of The American Society of Mechanical Engineers as associate editor. His talents were employed on the Society's "Journal", now known as "Mechanical Engineering," and on the editing of engineering and technical papers for the "Transactions" of the Society.

Charles Edward Eveleth, vice-president of the General Electric Company, died at Schenectady, March 25th, following an illness of several months. He had been with the company since his graduation from Worcester Polytechnic Institute in 1899, and had been a vice-president since April, 1927. As vice-president he was at first associated with C. C. Chesney and W. R. Burrows in the management of the manufacturing department of the General Electrical Company. In 1929 he was transferred to the engineering department in association with Vice-President E. W. Allen.

NEW EQUIPMENT

of interest to steam plant Engineers

Flexible Coupling

Link-Belt Company, Indianapolis, Indiana, announces the development of a new flexible coupling in which the Company's recently-announced "RC" Silverlink Roller Chain will be used.

The new coupling, to be known as the Link-Belt "RC" Flexible Coupling, consists simply of two cut-tooth sprocket wheels (or coupling halves) and a piece of roller chain to connect them, all working surfaces being machined to close tolerances. A pin-and-cotter link makes it easy to couple or remove the chain when desired.

Where the operating conditions suggest the advisability of protection from dust, dirt or other adverse conditions, the coupling can be enclosed in either

a stationary or revolving automatically-lubricating oil-retaining casing.

The standard sizes of couplings and both types of casing are illustrated, listed and described in a new folder which the Company will send to anyone upon request.

Portable Vibrometer

For power plant, field and service work, and for general testing, a new vibrometer is announced by the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa. The accuracy and compactness of the device are especially valuable for vibration studies on small machines or where clearance is limited.

The instrument consists of a flexibly supported mass, and a dial indicator fastened to the end of a thumb, screw and supported by the mass, to measure the amplitude. Vertical movements are measured with the adjustment shown in the illustration, but for indications in the other two principal planes the dial indicator is turned through ninety degrees by means of the thumb screw. To facilitate this adjustment the end of the indicator bears on a circular block. The dial is read through the cutaway portions of the mass by sighting from the

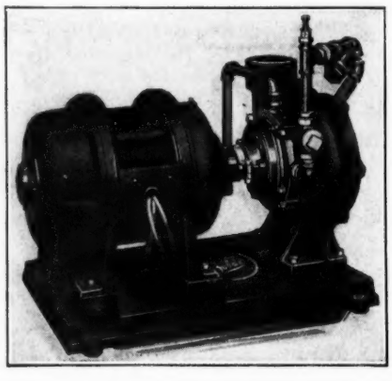
side. Laboratory tests show that the vibrometer is reliable for frequencies as high as 6000 r.p.m. when the amplitude does not exceed 0.004 in., and at lower speeds for much higher amplitudes.

The chromium-plated vibrometer is furnished with a micarta carrying case which is not too large to slip into a brief case.

Single Suction Self-Priming Pump

A new single suction pump has been developed and placed on the market by the Buffalo Pumps, Inc., Buffalo, N. Y. This pump has a built-in self-primer which is included in the pump design under license from the Nash Engineering Co., and is exactly the same as those built by the latter company for several years.

This new pump, which is known as the Buffalo type "CP," is claimed to be a compact, rugged and economical unit. The casing is of cast iron and the suction side-plate is template-drilled, with close clearance with impeller. Two types of impellers are available, namely, the open type and enclosed type. The open type is best suited for sump service or wherever the liquids to be pumped are not clear. The enclosed type is commonly applied for all services where clear liquids are pumped. For general

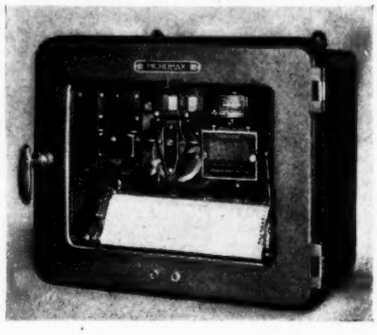


usage bronze impellers are used, but when required these impellers are made of iron or other metals.

The self-priming device is mounted as an integral part of the pump casing. The bronze covered pump shaft is an extension of motor shaft and carries impellers for pump and primer. The design of this pump does not require special bearings or couplings. Both the radial and thrust loads are taken by the motor bearings. The gland is of the split type and is of cast iron. On special order it can be supplied made of bronze. The pump is built in sizes ranging up to 450 gal. per min. and for heads up to 150 feet.

Recorder Case

A new multi-purpose case for the Micromax Recorder has been made available by the Leeds & Northrup Company, Philadelphia, Pa. This sturdy case is dust-tight, and, when desired, vapor-tight. It can be supplied for mounting in any position as specified—either flush in panel, on front of panel or wall, or on table or bench. The case is sealed by simply turning the handle, thus pressing the door tightly against a rubber gasket. The lock is outside the gasket, and hence vapors cannot filter into the case through it. The switches for motor, lights and control circuit are operable externally and are vapor-proof, so that these units may be shut off be-



fore the door is opened and outside vapors reach the mechanism. Leads to the Recorder can be brought in through either conduit connections or a pothead. The Recorder complete with chart reroll has the same listing as the former glass-side case without reroll.

The mechanism can be swung completely out of the case, so that it is accessible from all sides. The machine is adapted to all types of control, remote recording, etc., and is furnished in any of the standard pull-type measuring circuits.

Portable Manhole Blower Is Engine Driven

For ventilating and driving off obnoxious gases from manholes, tunnels and generally enclosed places where electric power is not available, a gasoline engine driven blower has recently been placed on the market by the Coppus Engineering Corporation, Worcester, Mass.

The new device is powered by a ¾ hp. air-cooled gasoline engine, operates at 1800 r.p.m. and delivers 1550 cu. ft. of air per min. This blower is mounted on heavy coil springs to cushion the vibration of the single cylinder engine. By means of an 8 in. dia. flexible tubing, the air flow can be directed to any

desired point. An adjustable discharge eliminates elbows in this duct.

The entire device weighs but 105 lb. and can easily be carried around and set up on any space two feet square or larger, for ventilating cable manholes, tunnels, pipe galleries, underground passages, coal pockets, process tanks, etc.

The Coppus Engineering Corporation also manufactures a similar device driven by an electric motor.

New Plastic Masonry Mortar

Cobbsment is the name of a plastic masonry mortar developed by the Glencoe Lime & Cement Company, 1608 Pine Street, St. Louis. This mortar is especially suited for use in building construction as it has such a low shrinkage factor that it can be used in setting flue linings of buildings, brickwork in chimneys, and in brickwork on exteriors of kilns, stills, boiler settings, dryers, etc., where temperatures do not exceed 900 deg. fahr.

Underfeed Stokers

The Patterson Foundry & Machine Company of East Liverpool, Ohio, who recently announced their entrance into the stoker field with an extensive line, have produced a new unit which they designate as their Standard Hydraulic model. This machine, in the unit type, with the hood removed to show the drive, is shown below.

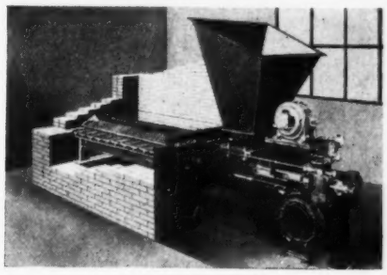
The motor is placed on top of an oil reservoir, which acts as a supply and overflow chamber. A small rotary pump, driven by V-Belt from the motor, submerged in this reservoir, provides pressure to operate the hydraulic ram piston, through a slide valve and regulating valve. By means of the regulating valve it is possible to get any desired speed on the ram, from nothing up to several revolutions per minute, the same as if steam driven. In addition, an adjustment is provided on the distributing rod so that the distribution of coal in the retort can be varied at will from outside. A relief valve is located in the oil reservoir to add additional protection against overloads in case motor controls fail.

This machine can be furnished with the fan V-Belt driven from the same motor that drives the pump, or with a separate motor driven fan located away from the boiler front, in the latter case controls being furnished to permit of either synchronous or separate operation. In addition to the usual controls, a machine limit switch is provided which always stops the machine with the ram in an advanced position, thus closing off all communication to the furnace when the stoker is down and preventing burning back to the hopper.

The grate area is made up of sloping, slot type tuyeres and slotted side dump bars, with the plenum chamber underneath divided into zones with damper control. Normally no air is admitted under the dump bars, but when it is desirable it can be obtained by simply opening the dampers, thus the entire surface can be made active.

Hoppers are hinged to tip either way and are provided with access doors near the bottom to permit removal of foreign matter without emptying the hopper.

This same stoker is available with gear drive, in which case a chain drives a crankshaft to give motion to the ram.



A reduction gear arrangement on the end of the motor reduces the chain speed to 5 r.p.m.

This stoker is designed for large heating or small power loads.

Feed Water Regulator

Northern Equipment Company, Erie, Pa., announces an improved design of the Copes Series Type Feed Water Regulator. This regulator feeds the boiler in accordance with steam flow, with compensation for water level. The new design has been developed as a result of tests made at Bohlen Power Station in Germany.

A new type of mechanical transmission makes it possible to locate the steam flow thermostat near the connections to the steam header. This simplifies erection and adjustment of the regulator, assuring more accurate results.

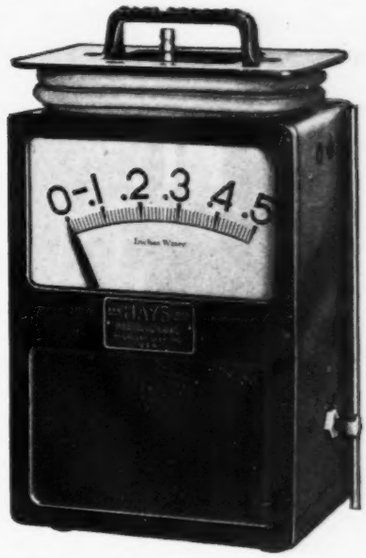
With the new Series Type Regulator, it is an easy matter to increase or decrease the influence of either steam flow or water level thermostat. This means that almost any desired proportion between steam flow and water level can be obtained.

The Series Type Regulator can be equipped with either direct-acting or hydraulically-operated control valve, or with a combined feed flow and water pressure regulating valve. Present installations of Copes Feed Water Regulators equipped with tension type thermostats may be changed over to Series Type Regulators at moderate cost.

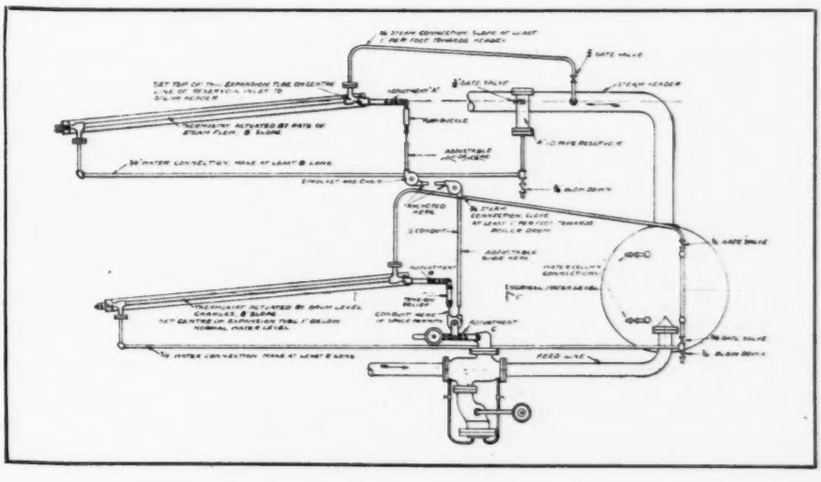
Portable Draft Gage

A new Hays (Dry Type) Portable Style Draft Gage has been developed and is now being marketed by the Hays Corporation, Michigan City, Indiana. This gage has been especially designed for heating engineers, service engineers, fuel dealers, installers of oil and gas burners, stokers, furnaces and boilers.

Some of the features claimed for this device are as follows: uses no liquids; can be set up for service in 30 seconds; has reel for carrying rubber tubing; is



compact, weighing only 4¾ lb. and measuring overall 5 in. by 4 in. by 9 in.; does not require leveling, gage may be placed on any convenient surface, pointer set to zero and readings taken.



NEW CATALOGS AND BULLETINS

Any of the following publications will be sent to you upon request. Address your request direct to the manufacturer and mention COMBUSTION Magazine

Ball Bearings

M-R-C Ball Bearing Catalog gives complete information on 37 different types of ball bearings manufactured by the Marlin-Rockwell Corporation. The catalog comprehensively sets forth the description and advantages of these ball bearings and also includes data relative to prices, dimensions, code, weights and designation, and also contains charts and tables. 24 pages and cover, 8½ x 11—Marlin-Rockwell Corporation, Jamestown, New York.

Desuperheaters

A new pamphlet No. 1417 entitled "Blaw-Knox Desuperheaters" describes and illustrates this new desuperheater. The operating principle of this device is very simple. It consists of the admission of steam into a vessel in such a manner that the steam mixes very intimately with water in the vessel and thus completely desuperheating the steam. 4 pages, 8½ x 11—Blaw-Knox Company, Pittsburgh, Pa.

Electric Weld Tubing

A pamphlet entitled "Republic Electric Weld Tubing" sets forth in three tables the data relative to Steel Tubing, Small Tubing and Toncan Iron Tubing. Physical characteristics and features are described. 4 pages, 8½ x 11—Republic Steel Corporation, Youngstown, Ohio.

Expansion Steam Trap

Bulletin 131 sets forth the design construction and principle of operation of the "Nicholson" Expansion Steam Trap. This device is suited to draining all industrial apparatus where steam is used; some of which are heating coils, dry kilns, paper machine rolls, steam separators, etc. List of prices and a partial list of users are included. 4 pages, 8½ by 11—W. H. Nicholson & Co., 12 Oregon Street, Wilkes-Barre, Pa.

Feed Water Regulator for Small Boilers

Pamphlet No. 8445 recently published by McDonnell & Miller, Grand Central Terminal, New York, describes the features of the McDonnell 37 Safety Feeder for Small Boilers under 2500 ft. radiation capacity. Pictures show the details of construction of this device and also the method of installation. 4 pages, 8½ x 11.

Furnace Draft Regulator

A pamphlet entitled "High Buildings with Low Fuel Bills" describes and illustrates the Carrick Furnace Regulator. It particularly sets forth the features which are claimed to recommend this device for use in power plants of high buildings. An article entitled "Why Ordinary Control is Unsatisfactory" is also included. Illustrations and charts. 8 pages, 8½ x 11, Carrick Engineering Company, Michigan City, Indiana.

Pressure and Vacuum Gages

Catalog G-6 describes and illustrates "Federal Warranted Gauges." Gages for every purpose and pressure and many for special applications are shown. Tables of prices and sizes are included. 12 pages, 8½ x 11—The Mercoid Corporation, 4201 Belmont Avenue, Chicago, Illinois.

Refractory Arches

Carbofrax Veneered Arches is the title of a pamphlet describing the refractory arch made by the Carborundum Company, Perth Amboy, N. J. Various types of arches equipped with Carbofrax Veneer are shown; also pictures of Carbofrax-Veneer-equipped arches and other refractory arches after the same period of exposure to furnace heat. 12 pages, 8½ x 11.

Rotary Pumps

Bulletin 5000 describes and illustrates an entirely new line of hydraulic pumps and motors of the rotary radial piston type which have recently been developed and placed on the market by the Northern Pump Company, Minneapolis, Minn. These pumps are designed to be used for high pressure lubrication, stoker drives, ash discharge rolls and other uses. Tables, drawings, etc. 4 pages, 8½ x 11.

Soft Rubber Bearings Applied to Machinery

A booklet on "Cutless Rubber Guide Bearings as Applied to Hydraulic Turbines" has just been published by The B. F. Goodrich Rubber Company, Akron, Ohio. The booklet which is profusely illustrated, goes exhaustively into the subject of Cutless Rubber Guide Bearings for hydraulic turbines and presents material that should be valuable to anyone making a study of bearing problems in any field. Subjects treated are: "Oil Lubricated Metal Bearings Present Difficulties Not Found in Water Lubricated Bearings"—"Rubber Bearings Resist Abrasion to a Remarkable Degree"—"Spiral Grooved Type Bearings"—"Segmental Type Bearings"—"Installation of Rubber Bearings in Existing Turbines"—"Amount of Lubricating Water Required for Cutless Rubber Bearings" and "Shaft and Shaft Sleeves." 22 pages and cover, 8½ x 11.

Synchronous Motors

Bulletin GEA-1195A recently issued, describes the main characteristics of G-E Synchronous Motors for Driving Metal-rolling Mills. These are some of the characteristics claimed for this motor: high starting torque—high pull-in torque—high pull-out torque—adapted for direct-connected, low speed drives of large capcaity. 4 pages, 8½ x 11—General Electric Company, Schenectady, New York.

Thrust and Journal Bearings

A catalog entitled "Kingsbury Thrust Bearings and Journal Bearings" sets forth the design, construction and applications of the above mentioned bearings. The numerous types are illustrated and the individual features pointed out. Detail drawings are included together with tables giving sizes, load capacities, weights, etc. 36 pages and cover, 8½ x 11—Kingsbury Machine Works, Inc., 4324 Tackawanna Street, Philadelphia, Pa.

Treatment of Condenser Cooling Water

A reprint has been recently issued entitled "Treatment of Condenser Cooling Water." This reprint discusses methods for the reduction and elimination of scale in condensers, and points out the large resultant fuel economy. Diagrams of typical installations, charts and tables are also included. 4 pages, 8½ x 11—The Permutit Company, 440 Fourth Avenue, New York.

Welded Boiler Tubes

A pamphlet entitled "Electrunite Boiler Tubes" sets forth general information relative to this new type of welded tube. These tubes are designed for use either in fire-tube or water-tube boilers requiring either straight or bent tubes. They have been approved by the A.S.M.E., the U. S. Steamboat Inspection Service and American Bureau of Shipping. 4 pages, 8½ x 11—Steel and Tubes, Inc., Cleveland, Ohio.

NOTICE

Manufacturers are requested to send copies of their new catalogs and bulletins for review on this page. Address copies of your new literature

COMBUSTION

to

200 Madison Ave., New York

REVIEW OF NEW TECHNICAL BOOKS

Any of the books reviewed on this page may be secured from In-Ce-Co Publishing Corporation, 200 Madison Avenue, New York

Fan Engineering

(Third Edition)

THE Buffalo Forge Company, Buffalo, N. Y., has just issued the third edition of its book *Fan Engineering*, which is a complete, up-to-date and reliable treatise on the theory and practice of fan applications for all purposes. As with the previous editions, most of the material contained is original, and many of the tables and charts are based on research done expressly for this publication.

The subject matter of the book has been divided into three parts, as follows:

Part I deals with the physical properties of air, heat and humidity, as well as the flow of air in general and as regards the fan in particular.

Part II relates to the application of air and air movements to the various classes of work for which fans may be adapted, such as heating, ventilation, humidifying and dehumidifying, cooling and refrigeration, drying, combustion and mechanical draft, dust elimination, etc.

Part III contains performance tables and general information concerning standard apparatus used in fan work.

In this latest edition of *Fan Engineering*, fully 100 pages have been added on the subjects of air, fans and fan applications. Many new types of air conditioning equipment are listed.

Bibliographies at the end of each section furnish suggestions for collateral reading. The appendix contains, in addition to the standard test code, 19 pages of miscellaneous and useful engineering data. A very comprehensive index, thoroughly cross-indexed, facilitates reference work.

The book is well illustrated and attractively bound in morocco fabrikoid, with rounded corners and gilt edges. It contains 622 pages, size 4⅜ x 7. Price $3.00.

Handbook of Chemistry and Physics

(17th Edition)

THE 17th edition of this well-known and valuable handbook has been subjected to an unusually extensive revision. Material covering more than three hundred pages in the 16th edition has been substantially changed. In nearly all cases completely new and larger tables are presented, involving an increase of over one hundred pages. Wholly new material, to the extent of fifty pages, has been added.

The most important revision has been that of the table "Physical Constants of Organic Compounds", which has been completely recompiled through the cooperation of 125 professors of organic chemistry representing the largest educational institutions in the country, and a number of directors of research of manufacturers of organic compounds.

Other important tables which have been completely revised are: Flame and Bead Tests; Standard Oxidation—Reduction Potentials; Cubical Expansion of Solids; Specific Heat of Gases; Specific Rotation; Wire Tables. A considerable addition has been made to the mathematical section of the book, including a very complete collection of "Integrals" and extensive "Interest Tables."

The following tables are among the more important of those now offered for the first time: Powers of Numbers; Factorials and their Logarithms; Factors for Computing Probable Errors; Probability of Occurrence of Deviations; Areas, Ordinates and Derivatives of the Normal Curve of Error; Arrangement of Electrons in Orbits; Correction of Boiling Points to Standard Pressure; Vapor Pressure, Variation with Temperature; Index of Refraction of Aqueous Solutions of Sucrose (cane sugar); Conversion Table for Transmission Units.

The book contains 1722 pages, including a comprehensive index, size 4¼ x 6¾. Price $6.00.

Bailey's Handbook

Of Universal Questions and Answers

(Sixth Edition)

THE questions and answers contained in this *Handbook* are those that have been universally asked by examining boards and were compiled from over four hundred examination papers, including tests for firemen, engineers and boiler inspectors. It gives information on the subjects of boilers, pumps, fuel consumption, valves, heating systems, engines, etc., and will be of assistance not only to those studying for any grade of license in this country or in Canada but also to the practical engineer and fireman.

The author, A. R. Bailey, is intimately acquainted with the needs of practical engineers and firemen and of candidates for licenses, having served as engineer and boiler inspector in the states of Massachusetts, Ohio, Pennsylvania and Michigan, and as safety engineer for the Lincoln Motor Company, Detroit. The sixth edition of this book, recently published, has been brought thoroughly up to date.

The book is well illustrated and contains 264 pages, size 4¾ x 6½. Price $2.00.

BOOKS For The Engineer

1—Power Plant Engineering and Design

By Frederick T. Morse

813 pages 6¼ x 9¼ Price $6.50

Professor Morse of the Louisiana Polytechnic Institute in the Preface to Power Plant Engineering and Design explains the purpose of his book as follows:

"This book is an attempt to present in one volume a thorough study of electric generating stations, including public service, industrial and institutional plants. In so doing, there has been no attempt to treat other than American practice. While the book is designed for use as a college text, it is hoped that the information it contains, and the method of presenting that information, will render it of value to the practicing engineer.

"The task of designing, constructing, and operating a power plant requires an understanding of both the mechanical and the electrical features of the plant. Furthermore, a book of this character should place due emphasis upon the economic factors underlying power plant design and construction. Hence, the writer has not attempted to divorce the mechanical and electrical features of the power plant, and has directed attention towards economy in power production."

2—Steam Power Plant Engineering

By G. F. Gebhardt

1036 Pages Price $6.00

One of the truly standard reference books on mechanical engineering. It is a necessary part of the equipment of everyone who has to do with steam-power plant engineering.

3—Science in Action

By Edward R. Weidlein and William A. Hamor

310 Pages Price $3.00

The authors, both connected with the Mellon Institute of Industrial Research, present in clear language, a sketch of the value of scientific research in American industry. This interesting and readable book is planned to give the business man, engineer and scientist a comprehensive picture of the place of science in industry—the means and methods of industrial research, the results achieved, the important factors in procedure and the choice of workers.

4—Symposium on Steel Castings

254 Pages Price $1.00

The presentation and publication of the ten extensive technical papers comprising the Symposium on Steel Castings have been sponsored jointly by the American Foundrymen's Association and the American Society for Testing Materials, the chief purpose being to provide the engineering profession with authoritative information on the properties of steel castings. Carbon-steel and alloy-steel castings are covered.

Extensive oral and written discussion adds to the value of the papers, presenting a broader view of the subjects. Diagrams, charts and tables have been extensively used by the authors to enable a quick and clear presentation of the data. .

5—Steam Tables and Mollier Diagram

By Joseph H. Keenan

Price $2.00

These new Steam Tables, extending to a pressure of 3500 lb. per sq. in. and a temperature of 1000 deg. fahr., were developed from the latest experimental data secured by investigators in laboratories of Europe and those of the United States. The Symbols used in this work are taken from the latest test prepared by the A. S. A. Sub-Committee for Heat and Thermodynamics. A large copy of the new Mollier Diagram (23" x 34") is also included.

6—Handbook of Oil Burning

By Harry F. Tapp

629 Pages Price $3.00

Contains information of practical value to the engineer or contractor whose work requires a knowledge of oil burning, heating or power equipment. Covers comprehensively the industrial application of oil as fuel, with drawings, illustrations and tables of this style of installation. Also discusses the various types of oil burner and principles of construction, oil burner controls and motors and fuel tanks and storage. Contains also a wealth of general information such as the chemistry of combustion and flame, fundamentals of heat and heat transfer, the determination of heating capacity requirements and comparative fuel costs.

7—Power Plant Management

By Walter N. Polakov

171 Pages Price $2.00

This book offers information of considerable value to those concerned with the management or supervision of power plants, and will help to solve many problems.

Today, power plant cost comes next to payroll as an expense item in textile finishing, paper products, food industries and other enterprises. If the application of efficient methods—checking layouts, costs, waste, etc.—in the generation, distribution and utilization of power, and especially in the scientific organization of the human element, savings of tens and hundreds of thousands of dollars are possible. It is to show management's place in creating these savings—to outline the simple proceedings necessary for the typical power plant, large or small—that this book was planned.

8—Kempe's Engineer's Year-Book for 1932

3000 Pages 7 x 5 $7.00

This publication brings together all the technical information which an engineer has to use day by day. It is a library in itself, a veritable encyclopaedia of modern practice in civil, mechanical, electrical, marine, gas, aero, mine and metallurgical engineering. It is of value to the practicing engineer, the consultant, the manufacturer, power user, contractor, works manager, draftsman and technical student. In this new edition, the 39th, up-to-date information and tables have been introduced, old matter re-arranged, and obsolete material omitted.

9—Economics for Engineers

By E. L. Bowers and R. H. Rowntree

490 Pages 6 x 9 Price $4.00

A practical presentation of economic principles and problems for engineers and engineering students. The treatment is as concise as possible and emphasizes the engineering aspects of economic theory and business activity. The discussion of costs and pricing is especially thorough. Some aspects of business activity, such as marketing, investments and insurance, not ordinarily included in texts on economics, are treated here for the convenience of the engineering audience to whom the book is addressed.

10—A Handbook of English in Engineering Use

By A. C. Howell

308 Pages Price $2.50

Here is a real up-to-the-minute handbook that should be on the desk of every technical writer. Most engineers today have occasion to do considerable writing and for those who have some doubt as to their ability to express themselves clearly, accurately and in acceptable form, Professor Howell's book will be of very definite value. The author takes a very practical point with regard to the engineer's professional use of language. Chapters are devoted to word usage and idioms, sentence and paragraph structure, composition, punctuation and the mechanics of writing and grammar. Examples cover letters, reports and technical articles.

Postage prepaid in the United States on all orders accompanied by remittance or amounting to five dollars or over.

IN-CE-CO PUBLISHING CORPORATION,
200 Madison Avenue, New York.

Enclosed find check for $.... for which please send me the books listed by number

NAME .....

ADDRESS .....

Books Nos. .....

Boiler, Stoker and Pulverized Fuel Equipment Sales

As reported by equipment manufacturers to the Department of Commerce, Bureau of the Census.

Boiler Sales

Orders for 34 water tube and h.r.t. boilers were placed in January.

	Number	Square feet
January, 1933	34	136,509
January, 1932	53	135,648
Total, 1932	641	2,124,361

NEW ORDERS, BY KIND, PLACED IN JANUARY, 1932-1933

Kind	January, 1932 Number	January, 1932 Square feet	January, 1933 Number	January, 1933 Square feet
Stationary:				
Water tube	26	107,652	24	122,324
Horizontal return tubular..	27	27,996	10	14,185
	53	135,648	34	136,509

Mechanical Stoker Sales

Orders for 63 stokers, Class 4*, totaling 12,248 hp. were placed in January by 42 manufacturers

	Installed under: Fire-tube boilers No.	Fire-tube boilers Horsepower	Water-tube boilers No.	Water-tube boilers Horsepower
January, 1933	50	7,468	13	4,780
January, 1932	70	10,306	45	23,936
Total, 1932	920	122,346	367	139,173

* Capacity over 300 lb. of coal per hr.

Pulverized Fuel Equipment Sales

Orders for 11 pulverizers with a total capacity of 73,850 lb. per hr. were placed in January.

	Total Number	No. for new boilers, furnaces and kilns	No. for existing boilers	Total capacity lb. coal per hour for contract	Number	Total sq. ft. steam generating surface	Total lb. steam per hour equivalent
STORAGE SYSTEM	Pulverizers				Water-tube Boilers		
January, 1933	..	..	..	.....	..	.....	.....
January, 1932	..	..	..	.....	..	.....	.....
Total, 1932	..	..	..	.....	..	.....	.....
DIRECT FIRED OR UNIT SYSTEM	Pulverizers				Water-tube Boilers		
January, 1933	10	10	..	72,600	5	64,434	655,000
January, 1932	7	5	2	29,600	6	3.,798	268,750
Total, 1932	73	48	25	392,388	64	463,194	3,536,260
					Fire-tube Boilers		
January, 1933	1	..	1	1,250	1	1,500	10,300
January, 1932	..	..	..	.....	..	.....	.....
Total, 1932	13	2	11	13,300	13	20,310	114,650

GLOBE SEAMLESS STEEL TUBES

GLOBE QUALITY SEAMLESS TUBES

are available in

Regular Carbon Steels
Copper Content Steels
Nickel Steels Chrome and Chrome Nickel Alloys

•

The New Globe "Electric Forge-Weld" Process permits the fabrication of single tubes from 40 to 80 ft. in length.

GLOBE STEEL TUBES CO.
MILWAUKEE, WIS.
Offices in Principal Cities

Specialists in bending, forming and upsetting

ADVERTISERS in this issue

The Buromin Company 4

Combustion Engineering Corporation .....Second Cover, 2, 40

Globe Steel Tubes Company..... 39

Hagan Corporation 4

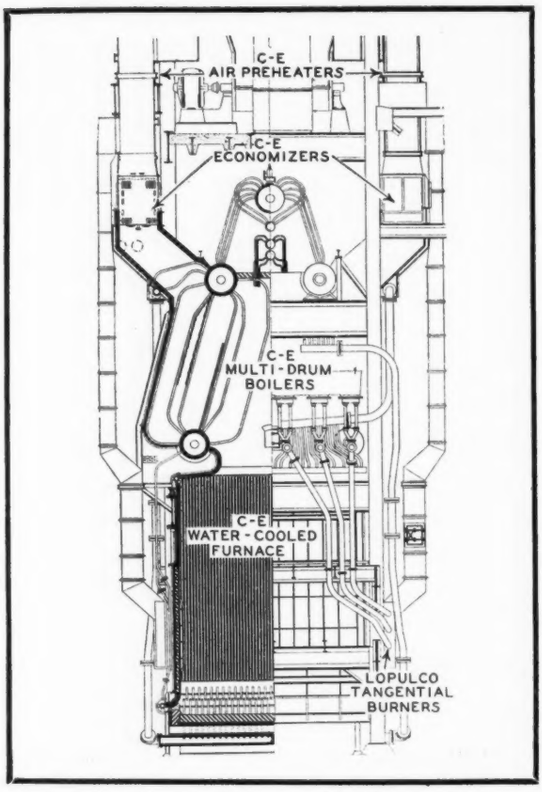
Hydraulic Couplings, Inc. 3

In-Ce-Co Publishing Corporation (Book Department) 38

Ingersoll-Rand Company .....Third Cover

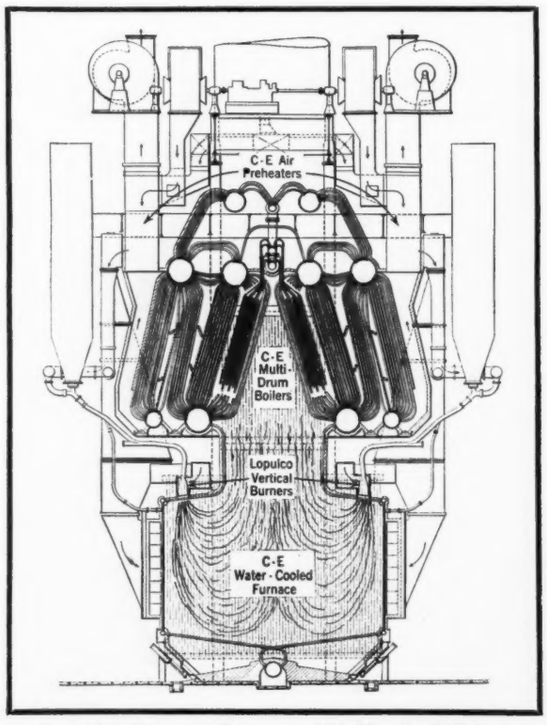
National Aluminate Corporation ..Fourth Cover

PULVERIZED FUEL



Lopulco Storage System with Corner Firing

as applied to one of two duplicate units—the largest super-pressure boilers in the world.



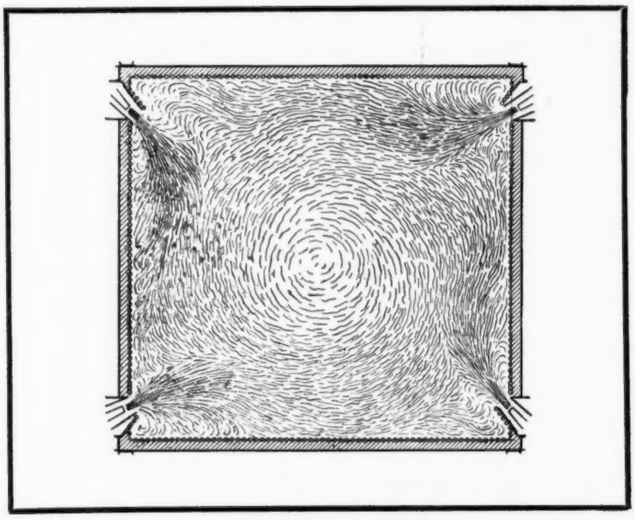
Lopulco Storage System with Vertical Firing

As applied to one of three duplicate units—the largest boilers in the world.

LOPULCO Pulverized Fuel Systems (storage and direct-fired types) are serving over 7,500,000 sq.ft. of boiler heating surface in the United States and Canada. Installations in South America, Europe, Asia and Africa increase this figure to well over 10,000,000 sq.ft. No other method of pulverized fuel firing has attained such world-wide recognition.

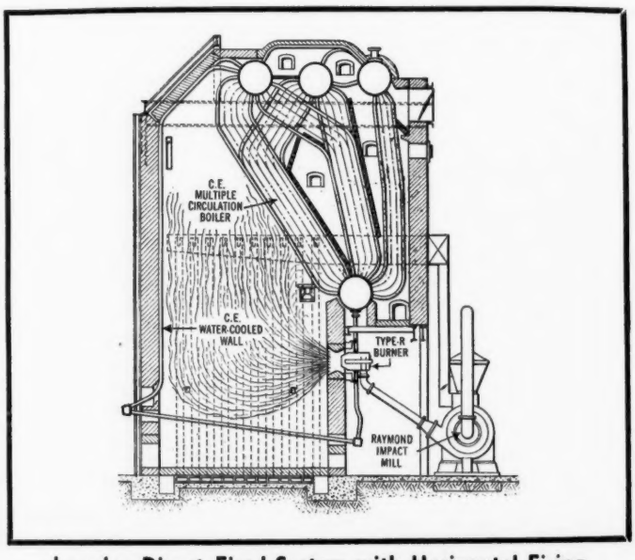
The several installations illustrated on this page typify the various arrangements and methods of firing for units ranging from 400 hp. up to and including the largest boilers built to date.

If you are considering the use of pulverized coal, either singly or in combination with oil or gas, *investigate Lopulco.*



Lopulco Corner Firing

Diagrammatic plan view of furnace opposite showing turbulence and intensive mixing effect.



Lopulco Direct-Fired System with Horizontal Firing

as applied to small boilers —from 400 hp. up.

COMBUSTION ENGINEERING CORPORATION

200 Madison Avenue - - New York